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PROCEEDINGS

of the

American Gas Institute

FOURTH ANNUAL MEETING

OCTOBER 20, 21, 22, 1909

DETROIT, MICH.

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JAMES W. DUNEAR 1906-1908

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(The authors only are responsible for their respective articles.)

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Chas. F. Richards.

Report of the Proceedings

of the

American Gas Institute

Fourth Annual Meeting

held at

Detroit, Mich.,

October 20th, 21st and 22nd, 1909.

The Fourth Annual Meeting of the American Gas Institute was called to order by the President, Chas. F. Prichard, in the Auditorium of the Elks' Hall, at 10.00 a. m., Wednesday, Oct. 20th, 1909. There were 462 members of the Institute registered as attending this meeting.

THE PRESIDENT: Gentlemen, will you please come to order. In a meeting like this, where we have so many new members and so many unfamiliar faces, it is very desirable that each member, on rising to speak, should announce his name, so that the stenographer can get a correct record.

The first business in order is the consideration of the minutes of the last annual meeting. These have been printed and distributed to all the members. What action will you take upon them?

MR. H. L. RICE: I move that the reading be dispensed with and the minutes as printed be approved.

The motion was seconded and carried.

REPORT ON ELECTION OF NEW MEMBERS.

THE PRESIDENT: The list of new members elected during the past year has been printed and distributed. I would suggest that the reading of these names be dispensed with in the

Directors' Report, in order to save time. Unless there is objection, we will proceed in that matter. I would say that we are very glad to have so many new members with us. The Directors at their meeting of last night voted that the privileges of the floor be extended to those gentlemen who have made applications, and on whose applications it is impossible to act until the next regular ballot. If the gentlemen who are here as new members will rise I am sure that the others will be glad to look into their faces.

The next thing in order is the reading of the

Directors' Report.

The Secretary then read the Directors' Report as follows:

October 20, 1909.

To The American Gas Institute,

Gentlemen: The Board of Directors has the honor to submit its Fourth Annual Report, as follows:

Meetings.

Three meetings of the Board have been held during the year, viz: February 10th and September 2nd, both at Headquarters in New York; and October 19th, at the temporary headquarters in the Hotel Pontchartrain, Detroit, Michigan.

Beal Medal.

The Beal Medal was awarded to Henry L. Rice, of Aurora, Illinois, for the best paper at the American Gas Light Association meeting of 1905, and to W. H. Gartley, of Philadelphia, for the best paper at the American Gas Institute meeting of 1906. This latter medal was struck from a new and very artistic die, made especially for the American Gas Institute.

Committee on Arrangements.

In accordance with By-Law 22, the following Committee on Arrangements for the Detroit meeting was appointed: Irvin Butterworth, Chairman; J. T. Lynn, J. J. Knight, B. O. Tippy, W. T. Barbour, W. S. Blauvelt.

Abstracts.

The publication of the Bulletin of Abstracts has been continued. With about 320 subscriptions, it is now on a self-supporting basis. The thanks of the American Gas Institute are due to The United Gas Improvement Company for furnishing, free of charge, the material for these abstracts.

Membership Committee's Report.

New members were added during the year as follows:

Election of April 1st.

Active	33	
Associate	13	
Junior	13	
	—	59
Transfers from Associate to Active	3	

Election of September 20th.

Active	25	
Associate	19	
Junior	11	
	—	55
Grand Total		114
Transfers from Junior to Active	2	

Summary.

New Active members (including transfers)	63		
New Associate members	32		
New Junior members	24		
Active members, Sept. 1, 1908		984	
Elected		58	
Transferred from other grades		5	
		1047	
Died	2		
Resigned	13		
Did not accept	3		
Dropped for non-payment of dues	48		
	—	66	
		——	981

Associate members, Sept. 1, 1908		232	
Elected		32	
		264	
Lost by transfer	3		
Died	3		
Resigned	3		
Did not accept	1		
Dropped for non-payment of dues	8		
	—	18	
			246
Junior members, Sept. 1, 1908		92	
Elected		24	
		116	
Lost by transfer	2		
Did not accept	3		
Dropped for non-payment of dues	5		
	—	10	
			106

Present Membership.

Active	981
Associate	246
Junior	106
Total	1333

The following is a list of new members elected:

ELECTION OF APRIL 1, 1909.

Active Membership.

Alrich, H. W., Engineer's Assistant, Consolidated Gas Co. of New York, 4 Irving Place, New York, N. Y.

Batten, J. W., Supt., Station "A," Detroit City Gas Co., Detroit, Mich.

Booth, W. F., Manager, South Shore Gas & Electric Co., Hammond, Ind.

Cross, F. L., Assistant Engineer, Detroit City Gas Co., 914 Porter St., Detroit, Mich.

Cushman, C. P., First Vice-President, Osaka Gas Co., Ltd., Osaka, Japan.

Dickey, E. Du-Val, Supt. Gas Dept., Beloit Water, Gas & Electric Co., Beloit, Wis.

Dunbar, C. H., Sec'y & Gen. Mgr., Houston Gas Co., 604 Main St., Houston, Tex.

Franklin, Gilbert, Assistant Engineer of Distribution, Consolidated Gas Co. of New York, 4 Irving Place, New York, N. Y.

Gerdenier, Charles M., Superintendent, Bridgeport Gas Light Co., Bridgeport, Conn.

Hagg, F. E., Auditor, Williamsport, Pa., Gas Co., 7 Wall St., New York, N. Y.

Haefelin, J. A., District Supt. of Mains, Consolidated Gas Co. of New York, foot of West 66th St., New York, N. Y.

Halsey, W. M., Chief Clerk, P. S. G. C. of N. J., Gas & Elec. Depts., 575 Broad St., Newark, N. J.

Henofer, J. P., Supt., Consumers' Gas Works, Hudson Div. P. S. G. C. of N. J., Halladay & Forest Sts., Jersey City, N. J.

Hodges, C. H., Asst. Supt., Consolidated Gas Co. of New York, 501 E. 21st., New York, N. Y.

Hudson, D. S., Asst. Supt. of Construction, Astoria L., H. & P. Co., Astoria, Long Island, N. Y.

Hunter, J. F., Asst. Engineer of Construction, Consolidated Gas Co. of New York, 4 Irving Place, New York, N. Y.

Livingston, H., Asst. Supt., Point Breeze Gas Works, The U. G. I. Co., Passayunk Ave. & Schuylkill River, Philadelphia, Pa.

Kingsbury, I. C., District Supt. of Mains, Consolidated Gas Co. of New York, 80 Elizabeth St., New York, N. Y.

McCabe, E. F., V.-P. & Gen. Mgr., Mifflin County Gas Co., Lewistown, Pa.

McCarthy, J. M., Vice-President, American Light & Traction Co., 40 Wall St., New York, N. Y.

MacIntosh, W. L., Engineer's Asst., Consolidated Gas Co. of New York, 4 Irving Place, New York, N. Y.

McMillin, Marion, Vice-President, American Light & Traction Co., 40 Wall St., New York, N. Y.

Nelson, J. F., District Supt. of Mains, Consolidated Gas Co. of New York, 111th St. & 1st Ave., New York, N. Y.

Palmer, A. J., Supt. Distribution, N. H. Dist. Hudson Div. Gas Dept., P. S. G. C. of N. J., 6th & Provost Sts., Jersey City, N. J.

Roberts, George W., Secretary and Treasurer, Bridgeport, Gas Co., Bridgeport, Conn.

Okamoto, Sakura, Chief Engineer & Manager, Nagoya Gas Co., Nagoya, Japan.

Smith, Raymond H., General Manager, Albany & Hudson Railroad Co., 140 State St., Albany, N. Y.

Steele, G. W., Manager, Lehigh-Northampton Light, Heat & Power Co., Catasauqua, Pa.

Strobridge, Wm., Engineer's Assistant, Consolidated Gas Co. of New York, 4 Irving Place, New York, N. Y.

Wakeman, C. E., General Manager, Glens Falls Gas & Electric Co., Glens Falls, N. Y.

Whitwell, L. M., Supt., Semet-Solvay Co., Milwaukee, Wis.

Wilke, A. C., Chemist, Milwaukee Gas Light Co., Milwaukee, Wis.

Associate Membership.

Claiborne, C. H., Rep., Union Mining Co. (Mfgrs. Fire Brick), 201 Fidelity Bldg., Baltimore, Md.

Fritz, H. C., Manager, Schneider & Trenkamp Div. American Stove Co., Chicago, Ill.

Gartley, Alonzo, Gen. Mgr., Hawaiian Electric Co., Honolulu, T. H.

Green, A. P., Consulting Engineer, with Evans & Howard Fire Brick Co., St. Louis, Mo.

Hodson, H. M., Mechanical Engineer, 38 Victoria St., London, England.

Hyland, E. F., Gas Inspector & Analyst, City of Detroit, Mich., Detroit, Mich.

Millar, P. S., Assistant Manager, New York Electrical Testing Laboratories, 80th St. and East End Ave., New York, N. Y.

Newbold, E. S., President, American Street Lighting Co., 831 Greenmount Ave., Baltimore, Md.

Roesler, H. A., Asst. Test. Dept. & Gas Engr., Fairmont Coal Co., Box 181, Fairmont, West Va.

Way, J. G., Mgr. Standard Lighting Co., Div. American Stove Co., Cleveland, Ohio.

White, Chas., Member of firm of White & Middleton, Gas Engine Co., Charles & Winder Sts., Baltimore, Md.

Young, N. A., Manager, James Gardner, Jr., Co., Bolivar, Pa.

Junior Membership.

Barnes, Geo. J., Foreman, 25th Ward Works, The U. G. I. Co., Richmond & Tioga Sts., Philadelphia, Pa.

Davis, E. B., Cadet Distribution Dept., Westchester Lighting Co., 205 Prospect Ave., Mt. Vernon, N. Y.

Houston, Gray Jones, Foreman of Works, San Antonio Gas & Electric Co., San Antonio, Tex.

Kellogg, R. C., Engineering Asst. Dept. of Mains & Services, Consolidated Gas Co. of New York, 4 Irving Place, New York, N. Y.

Kingsbury, I. Clayton, Asst. Superintendent Dept., Consolidated Gas Co. of New York, foot of W. 66th St., New York, N. Y.

Mansfield, J. H., Asst. Supt. Disn. Dept., Consolidated Gas Co., 80 Elizabeth St., New York, N. Y.

Nelson, E. A., Engineering Asst. of Mains and Services, Consolidated Gas Co. of New York, 4 Irving Place, New York, N. Y.

Paige, C. E., Superintendent, Malden & Melrose Gas Co., Malden, Mass.

Paleske, W. J., Receiver in Gas Office, Peoples Gas Light & Coke Co., 157 Michigan Ave., Chicago, Ill.

Peden, H. L., Asst. Supt. Distribution Dept., Consolidated Gas Co. of New York, 111th St. and 1st Ave., New York, N. Y.

Rasch, Wm. T., Engineering Asst., Dept. of Mains and Services, Consolidated Gas Co. of New York, 4 Irving Place, New York, N. Y.

Von Starzenski, V., Asst. to Supt. of Works and Distribution, Mohawk Gas Co., Schenectady, N. Y.

Stull, C. R., Cadet Engineer, Suburban Gas Co., Chester, Pa.

Transfer Associate to Active Membership.

Dudley, A. D., New Business Agt, Syracuse Lighting Co., Syracuse, N. Y.

Pearson, J. A., Purchasing Agent, The U. G. I. Co., 1401 Arch St., Philadelphia, Pa.

Welch, J. S., New Business Dept., The U. G. I. Co., 1401 Arch St., Philadelphia, Pa.

ELECTION OF SEPTEMBER 20, 1909.

Active Membership.

Allen, Wm. H., Jr., Asst. Supt. Coke Oven Dept., Solvay Process Co., Detroit.

Beatty, J. K., Gen. Supt. Phila. Co., Pittsburg, Pa.

Bertke, W. A., Superintendent, Pueblo Gas & Fuel Co.

Bimson, John, Jr., Supt. Distribution, Public Service Gas Co., Paterson, N. J.

Booth, Arthur, Asst. Gen. Pur. Agt., Philadelphia Company, Pittsburg, Pa.

Burden, Wesley W., Mechanical Engr., Astoria Light, Heat & Power Co.

Collins, J. Clarence, Secretary & Auditor, Railway and Light Co., Rochester, N. Y.

Douglas, Jas. B., Claim Agent, U. G. I. Co., Philadelphia.

Hunter, Chas. W., Supt. of Construction, People's G. L. & C. Co., Chicago.

Kowalke, Otto L., Asst. to Consulting Engineer and Instructor in Chemical Engineering, University of Wisconsin.

Lambert, Edw. L., Supt. & Treas., St. Charles (Mo.) Ltg. Co.

Lane, Jas. M., Supt. of Works, Public Service Gas Co., Paterson, N. J.

Leland, Edw. D., Supt. of Compressing Stations, Philadelphia Co., Pittsburg, Pa.

Martin, Eugene S., Supt., Westchester Ltg. Co., White Plains, New York.

McCloy, Walter L., Asst. to Gen. Supt., Philadelphia Co., Pittsburg, Pa.

Miller, Robt. C., Asst. Supt. Coke Dept., Consolidated Gas Co. of N. Y.

Mueller, Max Emil, Asst. Supt. of Mnfr., Astoria L., H. & P. Co.

Partridge, Warren, Gen. Supt., Springfield (Ill.) Ry. & Lgt. Co.

Powell, David A., Supt. Gas Dept., Madison, Wisconsin.

Prichard, Chas. R., Supt., Beverly (Mass.) G. & E. Co.

Reed, James H., Jr., Gen. Pur. Agt., Phila. Co., Pittsburg.

Rutledge, Fred J., Commercial Agt., U. G. I. Co., Philadelphia.

Sterling, Nath. Jos., Asst. Supt., Mechanical Dept., Astoria (L. I.) L., H. & P. Co.

St. John, John, Sec'y. & Treas., Madison (Wis.) G. & E. Co.

White, Alfred H., Consulting Engineer and Instructor of Class in Gas Engineering, University of Michigan.

Associate Membership.

Bates, Fred'k C., with General Electric Co., New York City.

Buell, Wm. C., Jr., Sec'y. & Gen. Mgr., Westmacott Gas Fur Co., Providence, R. I.

Caldwell, Jas. Henry, Vice-Pres. & Gen. Mgr., Ludlow Valve Co., Troy, N. Y.

Dreyfus, Edwin D., Commercial Engineering Work, Westinghouse, Pittsburg.

Foersterling, Dr. H., Second Vice-Pres., Roessler & Hasslacher Chem. Co., Perth Amboy, N. J.

Franklin, Wm. B., Sales Agt., U. S. C. I. P. & F. Co., Philadelphia.

Hake, Edw. W., Vice-Pres. & Gen. Mgr., Monitor Stove & Range Co., Cincinnati.

Kirchberger, Moritz, Pres., Crescent Burner Co., N. Y.

Lansingh, Van Rensselaer, Gen. Mgr., Holophane Co., N. Y.

Macbeth, Norman, Illuminating Engr., Welsbach Co., Gloucester, N. J.

Mason, John Ambler, Supt. for Bartlett, Hayward & Co., Baltimore, Md.

McDonald, Fred'k, Gas Meter Mfgr., Albany, N. Y.

Sard, Russell E., Treas., Rathbone, Sard & Co., Albany, N. Y.

Schmidlapp, W. H., Pres., Monitor Stove & Range Co., Cincinnati, O.

Sheppard, Howard R., Mem. firm I. A. Sheppard & Co., Philadelphia.

Sommer, Albert, Engineer Chemist of Texas Co., N. Y.

Thompson, Wm., Vice-Pres. & Gen. Mgr., Kalamazoo (Mich.) Stove Co.

Wardell, Chas. W., Illuminating Engr., Welsbach Co., Gloucester, N. J.

Wilmot, Jas. Edw., Mfgr. & Salesman, Gas Tip & Self-Lighter Co., 149 Church St., N. Y.

Junior Membership.

Beers, Dan'l N., Engineer, Indiana (Fort Wayne) Fuel & Lgt. Co.

Durkee, Chas. Chester, Cadet Engineer, Knoxville Gas Co., Tenn.

Gross, Harry O., Chief Inspector, St. Ltg. Dept., U. G. I. Co., 22d St., Philadelphia.

Kellogg, Harrison B., Cadet Engineer, Westchester Ltg. Co., Mt. Vernon, N. Y.

King, Arthur Gordon, Engr. & Chemist, Roanoke (Va.) G. & W. Co.

Klug, John Fred'k, Foreman Mnfr. Dept., Knoxville (Tenn.) Gas Co.

Lafore, Paul Jules, Asst. Gen. Dist. Foreman, Philadelphia Gas Works, U. G. I. Co.

Onderdonk, Latrobe H., Commercial Agt., San Antonio (Texas) G. & E. Co.

Perkins, Matthew F., Chief Canvasser, U. G. I. Co., Philadelphia.

Shaw, Chas. D., Jr., Asst. Foreman, U. G. I. Co., Philadelphia.

Stilwell, John, Engineering Dept., Consolidated Gas Co. of N. Y.

Transfer Junior to Active Membership.

Dickey, Sam'l J., Engineer with The United Gas Imp. Co., Philadelphia.

Milligan, A. L., Supt., Semet-Solvay Co., Chester, Pa.

Library.

A number of important additions to the Institute Library have been made during the past year. Enough volumes of the English Journal of Gas Lighting were purchased to make up a complete set from 1873 to date.

Mr. A. B. Slater has recently donated to the Institute a very valuable collection of American, English and Continental gas and other technical journals, technical books, reports and pamphlets. Among them are the early volumes of the English Journal of Gas Lighting, so that the library now has a complete set of this journal to date.

Secretary's Report of Sales of Badges.

Badges on hand Sept. 1, 1908		214
Returned by member resigning		1
Purchased during fiscal year ending		51
To account for		266
Sold during fiscal year	206	
On hand Sept. 1, 1909	60	
		266

Secretary's Report on Proceedings.

	On hand 9/1/08	Sent to members and exchanges, or sold	In stock 9/1/09
Volume I	492	235	257
Volume II	287	53	234
Volume III, from printer	1650	1360	290

Report of the Treasurer.

New York City, September 15, 1909.

To the Board of Directors, American Gas Institute.

Gentlemen: –I have the honor to present herewith the Report of the Treasurer for the fiscal year ending August 31, 1909.

Receipts.

Balance in Columbia Trust Co., Sept. 1, 1908	$ 1,749.75
Balance in Petty Cash Account	25.00
Received from dues	11,302.00
Received from Initiation Fees	1,910.00
Received from Sale of Badges	773.00
Received from Sale of Proceedings, etc.	662.87
Received from Abstracts, Subscriptions and Sales	2,694.70
Received from Interest on Bank Balances	134.74
Received from Miscellaneous Sources	7.33
Total	$19,259.39

Expenditures.

Storage	$ 101.25
Rent and Expense Headquarters	1,548.36
Reporting Director's Meetings	248.00
Expenses New York Meeting	808.01
Printing and Stationery	549.84
Office Fixtures	84.92
Postage, Express and General Expense	395.68
Premium on Surety Bond	40.00
Books and Binding for Library	89.88
Publishing and Mailing Abstracts	3,071.02
Publishing and Delivering Proceedings and Advance Papers	5,866.57
Salaries	3,012.50
Clerical Assistance	846.68
Badges Bought	181.30
Subscriptions, Gas Educational Fund	350.00
Balance in Petty Cash Account, Sept. 1, 1909	48.24
Balance in Columbia Trust Company	2,017.14
Total	$19,259.39

Respectfully submitted,

ALBERT B. BEADLE, Treasurer.

The Brooklyn Union Gas Company, Office of Chief Engineer,
Kent Avenue and Cross Street.

Brooklyn, N. Y., September 27, 1909.

Referring to Report of the Treasurer.

To the Board of Directors, American Gas Institute,
25 West 39th St., New York.

GENTLEMEN:—Enclosed herewith please find report of the Treasurer for the fiscal year ending August 31, 1909. Your Finance Committee has audited the books, accounts and statements of the Treasurer, and finds the report to be correct.

Respectfully submitted,
J. H. JOURDAN, Chairman.
WALTON FORSTALL,
J. ARNOLD NORCROSS.

SUPPLEMENT TO TREASURER'S REPORT.

Cash Statement from Sept. 1, 1908, to Oct. 1, 1909.

Received from dues, etc.	$6,888.75
Balance September 1	2,065.38
	$8,954.13
Expenditures to October 15th	1,467.41
Balance October 15th	7,486.72

Amounts Outstanding for Dues, etc.
(Prior to September 1, 1909.)

For year ending September 1, 1909	$1,255.00
For year ending September 1, 1908	475.00
	$1,730.00
Unpaid Abstract Subscriptions	425.00
Total Outstanding	$2,155.00

LIABILITIES, none, except for current bills.

Estimate of Receipts and Expenditures for Year Ending September 1, 1910.

Receipts.

Dues, 1,227 Active and Associate, at $10..	$12,270	
Dues, 106 Junior, at $5	530	
Initiation Fees, New Members	1,000	
Abstract Subscriptions, 320 at $5	1,600	
Sale of Badges, 100 at $3.75	375	
Sale of Proceedings, etc.	400	
Interest on Bank Balances	135	
Balance, September 1, 1909	2,065	
		$18,375

Expenses.

Rent, office	$ 1,550	
Rent, Store Room	40	
Reporting Director's Meetings	100	
Expenses Detroit Meeting	600	
Printing and Stationery	600	
Office Equipment	100	
Postage, Expenses and General	400	
Premium on Surety Bond	40	
Books and Binding	100	
Publishing and Mailing Abstracts	1,500	
Subscription Gas Trustees	350	
Badges for Stock	175	
Publishing and Delivering Proceedings and Advance Papers	4,000	
Salaries	3,000	
Clerical Assistance	720	
Contingencies	500	
		$13,775
Estimated Surplus		$4,600

Report of Trustees Gas Educational Fund.

The Annual Report of the Trustees Gas Educational Fund will be presented at this meeting to the Institute as one of the subscribers to the fund.

The Board recommends that the Institute continue its annual subscription of $350 to the Trustees Gas Educational Fund. The Board has also decided that in the forthcoming volume of the Proceedings, there be printed such of the questions and answers as have not been already printed in the volumes of the Institute Proceedings.

Life Membership.

The Directors, in accordance with Section 18 of the Constitution, have admitted to life membership, without dues, Mr. G. A. Hyde, of Cleveland, Ohio.

Illinois Gas Association Papers.

Two papers covering valuable original work have been received from the Illinois Gas Association under the affiliation agreement, as follows:

"Investigation of the Effects of Compression and Transmission on the Candle-Power and Heat Units of Manufactured Gas."

"The Comparative Values of Various Coatings and Coverings for the Prevention of Soil and Electrolytic Corrosion of Iron Pipe."

These papers have been accepted by the Technical Committee and Board of Directors, and may be found in full in the proceedings of the Illinois Gas Association for 1909, to which those interested are referred.

Reports of Committees.

The reports of the Public Relations and Technical Committees have been approved by the Directors, and will be submitted to the members in the course of the meeting.

The reports of the following sub-committees of the Tech-

nical Committee have been approved for reading at this meeting:

Calorimetry. J. B. Klumpp, Chairman.

Benzol Enrichment. J. D. Shattuck, Chairman.

Electrolysis. A. G. Glasgow, Chairman.

Unit of Light. A. C. Humphreys, Chairman.

Utilization of Gas Appliances. W. J. Serrill, Chairman.

Standard Pipe Threads. (Delegates).

Bureau of Information. W. A. Baehr, Chairman.

Wrinkle Department. F. L. Cross, Editor.

Papers to be Read at Meeting.

The following papers have been approved by the Technical Committee and the Directors, and will be read at this meeting:

"Technical and Mechanical Progress in the Gas Industry," Irvin Butterworth.

"Sliding Scale Regulation of Prices and Dividends," Alfred E. Forstall.

"Illuminating Engineering in Its Practical Applications," Norman Macbeth.

"Tar as Applied to the Surface Treatment of Roads," Hervey J. Skinner.

(Contribution from the Laboratory of Arthur D. Little.)

"Vertical Retorts," Walter G. Africa.

"The Development of Oil Gas in California," Edw. C. Jones.

"Sulphur Compounds in Illuminating Gas," Charles J. Ramsburg.

"Identification of Gas Oils," F. E. Park and L. E. Worthing.

"Power Plants for Gas Works of Medium Size," Charles D. Robison.

"Gas in the Modern Kitchen," George W. Thomson.

"Commercialism," Charles M. Cohn.

"The Solicitor," Karl A. Schick.

"Automatic Oiling Meters," T. D. Miller.

"Booster System at Rochester," Frank Hellen.

"Acceptance and Interpretation of Data," Robert O. Luqueer.

In addition to the papers submitted to the Technical Committee, Mr. Chas. D. Lamson has kindly consented to read his paper on "A Pound of Coal," as read before the Society of Gas Lighting," and Dr. Edw. P. Hyde will deliver a lecture on "The Relation of Natural Science to the Development of Lighting."

Recommendations.

The Board of Directors recommends that there be appointed by the President, after consultation with the Technical Committee, a representative to attend the meetings of the International Photometrical Commission.

The Board of Directors recommends the following changes in the Constitution, as approved by the Committee on Constitution and By-Laws.

Section 9. Strike out the entire section and substitute the following:

"Honorary members shall be proposed by the Directors to the members of the Institute by mailed notifications immediately after any annual meeting, and shall be voted upon by letter ballot at the time of the regular September ballot next following."

Section 54. Strike out the entire section and substitute the following:

"Section 54. The Directors shall meet the day before each general meeting of the Institute, and also on such day between June 1st and September 15th, both inclusive, as may be designated by the President by notice given at least one week in advance of meeting. Special meetings may be called when the President shall deem it necessary, and the President

shall be required to call a special meeting at any time on the written request of five members of the Board. Of such special meetings reasonable notice shall be given by special call, in print or writing, specifying the business to be attended to."

Section 55. Strike out the entire section and substitute the following:

"Section 55. The Board of Directors may in its discretion make with any one (or each) of the district and state gas, or gas and electric, associations, now existing or hereafter to be formed, agreements for co-operation between the Institute and such associations. Each and every such association with which such agreements are entered into, shall covenant as follows: Not to elect to voting membership any person connected in any way with the gas industry, who is not directly identified with gas, or electric interests, within the state or district designated by the name of the association; and to consult with the Institute before undertaking any original work of interest to the gas profession. All original work carried on by an affiliated association under this agreement shall, when completed and accepted by that association, be presented to the Institute for approval, and when so approved shall be incorporated in the Proceedings of the Institute in such form as the Directors shall determine. Each and every such association shall during the continuance of such agreements, be entitled to elect one of its members a member of the Board of Directors of the Institute, the members so elected to be in addition to those named in Section 23, provided that the number of such associated Directors shall never exceed one-third of the total membership of the Board. Should the Board of Directors provide for an executive committee, this committee shall include in its membership one man from each of the affiliated associations as long as the number of such associations does not exceed six. Thereafter there shall be on the executive committee at least six men

who are members of affiliated associations and have among them membership in at least six such associations."

All of which is respectfully submitted for the Board of Directors.

CHAS. F. PRICHARD, President.
ALBERT B. BEADLE, Secretary.

THE PRESIDENT: You have heard the report of the Board of Directors. What action shall be taken upon it?

MR. DONALD MCDONALD, of Louisville, Ky.: I move that the report of the Board of Directors be accepted and spread upon the minutes.

The motion was seconded and carried.

THE PRESIDENT: There are several recommendations made by the Board of Directors, which should be taken up one by one. The first is that the Board recommends to the Institute that it continue its annual subscription of $350 to the Trustees of the Gas Educational Fund. What action will you take upon that recommendation?

MR. EGNER: I move that it be adopted.

The motion was seconded and carried.

THE PRESIDENT: The Board of Directors recommends that there be appointed by the President, after consultation with the Technical Committee, a representative to attend the meetings of the *International Photometrical Commission*. What action shall be taken upon that recommendation? Would you like to say anything about that, Mr. Gartley?

MR. GARTLEY: I move that it be concurred in.

The motion was seconded.

MR. GARTLEY: I want to say that the proposition coming from the International Photometrical Commission gives us one delegate. There are 18 all together, four from Germany, four from England, and four from France, with six scattering. It is held by a number of gentlemen, who are conducting laboratories and looking into photometrical mat-

ters, that we, as the members of the Gas Institute—which is the only body that has the privilege of appointing a delegate to that International Commission—should keep ourselves in line with this photometrical work, in order that there may be a convergence of methods instead of a divergence.

THE PRESIDENT: It has been moved and seconded that the recommendation of the Board of Directors in regard to the appointing of a delegate to attend the meetings of the International Photometrical Commission be accepted. Those in favor of that motion will manifest it by saying aye. Those opposed. It is a vote.

The next recommendation is that the Board of Directors recommends the following changes in the constitution:

Striking out the entire section 9 and substitute the following:—

"Honorary members shall be proposed by the Directors to the members of the Institute by mailed notifications immediately after any annual meeting, and shall be voted upon by letter ballot at the time of the regular September ballot next following."

What is your pleasure in regard to that recommendation?

MR. EGNER: Mr. President, I move that it be adopted.

The motion was seconded and carried.

THE PRESIDENT: Another recommendation is in regard to Section 54. Strike out the entire section and substitute the following:

"The Directors shall meet the day before each general meeting of the Institute, and also on such day between June 1st and September 15th, both inclusive, as may be designated by the President by notice given at least one week in advance of meeting. Special meetings may be called when the President shall deem it necessary, and the President shall be required to call a special meeting at any time on the written request of five members of the Board. Of such meetings reasonable notice shall be given by special call, in print or writing, specifying the business to be attended to."

What action shall be taken upon that recommendation?

Mr. W. R. Addicks: I move that it be adopted.

The motion was seconded and carried.

The other recommendation is in regard to Section 55. Strike out the entire section and substitute the following:

"The Board of Directors may in its discretion make with any one (or each) of the district and state gas, or gas and electric, associations, now existing or hereafter to be formed, agreements for co-operation between the Institute and such associations. Each and every such association with which such agreements are entered into, shall covenant as follows: Not to elect to voting membership any person connected in any way with the gas industry, who is not directly identified with gas, or electric interests, within the state or district designated by the name of the association; and to consult with the Institute before undertaking any original work of interest to the gas profession. All original work carried on by an affiliated association under this agreement shall, when completed and accepted by that association, be presented to the Institute for approval, and when so approved shall be incorporated in the Proceedings of the Institute in such form as the Directors shall determine. Each and every such association shall during the continuance of such agreements, be entitled to elect one of its members a member of the Board of Directors of the Institute, the members so elected to be in addition to those named in Section 23, provided that the number of such associated Directors shall never exceed one-third of the total membership of the Board. Should the Board of Directors provide for an executive committee, this committee shall include in its membership one man from each of the affiliated associations as long as the number of such associations does not exceed six. Thereafter there shall be on the executive committee at least six men who are members of affiliated associations and have among them membership in at least six such associations."

MR. RICE: I move that the recommendation be adopted.

The motion was seconded and carried.

The President at this point requested the first Vice President, Mr. Gartley, to take the chair while he read his address.

The President then read his address as follows, at the conclusion of which there was great applause.

PRESIDENTS ADDRESS.

It gives me greet pleasure to great you on this our Fourth Annual Convention, or what is really the Thirty-Seventh Convention if we go back to the organization of the oldest of the associations which amalgamated to form the American Gas Institute.

We meet in a most beautiful and cordial City, convenient of access to our members, at a season when work is no hardship, and in a time of returning and assured business prosperity.

Our committees of the year have done a vast amount of work, some of which has already appeared in the Journals.

Our Technical Committee has arranged a program embarassing in its lavishness, timely in its topics, and giving much food for thought to all classes of our membership, and our Committee of Arrangements has looked after our welfare and provided those opportunities for social intercourse which do so much to weld together the members of a body like this.

Possibly if your officials had power to enforce their requests and were catering to a body whose tastes were identical in all respects, we might have attained one hundred per cent. efficiency, having each detail satisfactory to each member, but there is no power to enforce in a body so loosely held together as this and the different classes of our members have their chief interests in different subjects. Beside this, much that we planned has failed of accomplishment through no lack of effort on our part, but we believe no one who participates in this meeting will regret his trip to Detroit.

Having in mind that matters of policy, commercialism,

chemical, technical and mechanical matters and the progress of the business during the year are cared for in the program, it seemed well for me to speak of some points in connection with the Institute, the industry and the program, rather than to discuss one or more technical points.

The Institute.

The American Gas Institute, now assembled for its Fourth Annual Meeting, comprises in its membership over thirteen hundred members, representing an industry with an investment of over $1,000,000,000.

The members of this body are directly responsible for the safety of this vast amount of money and are charged with the duty of employing it not only to advantage, but to the best possible advantage.

We have upon us the burden of so caring for this property that it shall be conserved to its utmost, that its direct depreciation shall be the least possible, and that its expenditure in new or untried fields of policy, in process or apparatus, in business methods or devices, shall be so wisely forecast as to produce the maximum result with a minimum expenditure. It is no great task to produce results with lavish expenditure. True management goes farther than this.

We are expected to handle the property placed in our control so that the stockholder shall have a fair return upon his investment, but we are expected also by the public, while doing this, to make a fair price to them for our commodity, and we are responsible for the quality and reliability of supply of what once was a luxury but now is a necessity.

Truly this is no light burden if done well, and as one of the means to this well doing, we meet here, the American Gas Institute, to consult, co-operate, interchange ideas, discuss methods of policy, of engineering or of salesmanship, or to take any other steps we may see fit, tending to the betterment of our industry or the property in our charge.

Such step may be the passing of a measure defining some particular unit, it may be the formal setting forth of some new

idea in policy, manufacture, or in the sale of our product, or it may be the informal meeting and discussion of some matter of common interest by men from the extremes of the country with their naturally varying views and requirements.

It is difficult to say which is the most valuable, the formal or the informal, but we who organize clubs with pianos and pool tables, ball teams and athletic sports, ,to promote loyalty and helpful comradeship among our workmen, that the benefit may in some measure return to our own undertakings, must not forget that we also are workmen in our field and should not ourselves neglect the social features we lay so much stress on for others.

In forming the American Gas Institute, three associations of national character were merged into one.

It is desirable that there should be no other association national in character. It was to be expected that many smaller associations occupying special territory or devoted to special branches should continue their associations, or that new ones should be formed, and such proves to be the fact. In the place of eleven associations existing at the time of the formation of the Institute, there are now twenty-two.

But the American Gas Institute should be the national body, the common meeting place, and the clearing house of the industry.

Wherever located, whether big or little, however owned or operated, we have three broad divisions of work common to all, which make necessary the co-operation and combination in the American Gas Institute of all workers in this industry for the protection and advancement of our business. They are the establishment and maintenance of proper relations between ourselves, the authorities and the public, the production and distribution of our product and its sale,—the business relations, the engineering or economic, and the commercial, the manager, the engineer, the salesman.

The meetings of the past, in this association and its predecessors, have been largely dominated by the technical thought.

The organizers of the Institute, however, recognized the necessity of dealing with matters of public policy and in the proceedings leading up to its formation the necessity of work in this direction was recognized and enlarged upon. Although in the establishment of our committees the Public Relations Committee was first named and given great prominence, the records of our proceedings show relatively little work done in this direction outside of the Committee reports.

I believe this is in part due, as stated before, to our being accustomed to regard these meetings as technical meetings. Possibly also it is due in part to the fear that these matters, some of which are of a delicate nature, may not be handled with proper tact and skill, but there are in our relations to the public, to the law making bodies and to the commissions, many matters about which we should go on record before the public, and many matters in which we should use our influence, properly, that our properties should have fair treatment.

If we do not take up this work, some other national body will in time and it would seem that the duties of the Public Relations Committee should be expanded to the extent of procuring for our program several papers dealing with these subjects each year.

On Commercialism we have no committees and have done but little work, and yet increased profits are largely obtained through development of business and the object of Commercialism is to develop the business. So little has been done that an organization has been formed, national in character, to cover this ground. That so little has been done is apparently due to the fact that many of our members did not realize the importance of this branch of our work. The importance has been made plain to us and the progress of this natural subdivision of our work should be before us each year as part of our program.

While it is of great value for our new business men, our salesmen and our demonstrators to meet the appliance man, the appliance man also wants to meet the manager, for it is

to him commercial schemes must be presented for discussion and approval. There is no better place than at this meeting of the national body, of the controlling minds of the companies.

Steps are being taken towards some form of amalgamation with the Commercial Association, and for the general good of our business, I trust you will give it your careful attention, and if necessary concede minor matters for the greater good of all.

While we have a large membership, we represent a much smaller number of companies, there being as I roughly count them some four hundred and twenty-five companies represented in the Institute. Representatives of relatively few of these companies take an active part in the proceedings.

Your President of last year made the startling statement that during a period of twelve years, about 50 per cent. of the papers had been contributed by representatives of two powerful interests.

It is natural that powerful interests should absorb a large percentage of the high grade men, as they naturally should offer better opportunities for advancement, and it is natural that men of these attainments should be the most ready contributors. Moreover, if such concerns are interested in the Institute, they can insist that their men should work for it, but such an extreme showing as is cited is undesirable. Powerful interests of this nature must necessarily be subject to a system which tends to give uniformity of results, and our papers if coming from but one or two sources might lack that element of originality which comes from independent effort. Too much inbreeding means disaster in the end, and if we can obtain our contributions only from a limited source, it means that some portion of our method is at fault.

There are in this broad country so many men handling large and small plants engrossed in problems having a greater or less bearing on our common work—there are so many things that everyone here can learn of policy, economy, or salesman-

ship from the representative of the smallest company on our list—that unless we draw them out formally and socially, we are cultivating but a portion of our field and not doing our best work.

Your President of last year has said that we need and must draw out new blood. That sentiment I heartily endorse,

We have made special effort this year not to discourage work from the more powerful interests, but to encourage others and to broaden the field of contributors. We think to a considerable extent we have been successful.

It is plainly apparent, however, that there is not that productive loyalty to the Institute, nor was there that productive loyalty to its predecessor the American Gas Light Association, that existed in the Western, the Ohio and other associations.

So far as I can ascertain by inquiry, there is but one reason for this lack of loyal and hearty support. It is that many members have lost interest or do not become interested, because they feel that they have little or no representation, that the course is predetermined and shaped regardless of them and often in spite of them. If this is true and they do not resent it, the word "American" has no place in the name of this body. On the other hand, as Dr. Humphreys said in his address last year in discussing this subject, "Where so much is contributed, those who contribute should be influential in determining the Institute's policy and procedure."

If this is a concise statement of the two views, there appears to be no good reason why conflict should exist if a reasonable amount of tact and a liberal application of that good old fashioned nerve tonic called the Golden Rule were used.

In the development of a business like ours it is necessary to present a harmonious and united front, and if we are to do our best work, no portion of our membership can do without the other.

Some of the best and most valuable improvements in apparatus and methods are coming and have come from sources

entirely independent of the large organizations. On the other hand the systematic training of the men in these organizations does much to promote continuous and progressive work along defined lines.

The Industry.

It is not unusual to find the statement from our competitors and sometimes from our friends, that our business has reached its maximum. The contrary is true, and we may well congratulate ourselves on the condition of our industry.

The returns of the Geological Survey show the increase of manufactured gas sold in 1908 over 1907 to be over 5 per cent., and this in spite of the prevailing depression in business during that year.

It is to be regretted that previous to 1907 these resords were not made in sufficient detail to carry the comparison farther back, but taking the returns of the Board of Gas & Electric Light Commissioners of Massachusetts, which are most carefully and accurately compiled, it will be found that the gas sold in Massachusetts in 1908 was 10,770,000,000, and in 1898 was 5,650,000,000, an increase of 90 per cent. in ten years. There was received by the companies in 1908 $10,433,-307., in 1898 $6,214,387., in spite of the fact that the average selling price in 1908 was 20 cents lower than in 1898 and the additional fact that over $10,000,000. was paid for electricity in 1908.

A comparison of the sales of gas in a number of the large cities and towns shows an enormous rate of increase. Ten, fifteen and even twenty per cent. increase per annum is not at all unusual. Cities can be found where the output of gas has doubled every six or seven years for a number of times, and instances are known of the business doubling in even a shorter time.

There is much said about the decrease of sales due to electric competition. Is it not an ally rather than a competitor? It has done much to educate the public to the use of more light and we have reaped the benefit of it. Together

we are working out the problem of illumination. In the old times we built fires to warm ourselves by. We had no thought of heating the entire house. So a few years ago we used light to enable us to see some special object. Now we aim to illuminate the entire space, and in this work we have the aid of electricity.

In the company which I represent we have a combined gas and electric plant, the revenue from each being substantially the same. The electric business has been established some twenty years. Our city has no features which differ from the average city and we aim to give to each customer what he wants, if he knows, and if he does not, we advise him to use what we believe will give him the greatest satisfaction, everything considered. Under such circumstances perhaps the rate of growth will be an indication whether or not we have need to worry about the inroads electricity may make on our revenue.

Leaving out the first ten years, when electricity was undeveloped, the rate of the past ten years is as follows:

Year	Gas sales per capita	Electric sales per capita
1899	$2.44	$2.35
1900	2.59	2.26
1901	2.84	2.37
1902	3.16	2.42
1903	3.51	2.62
1904	3.61	2.95
1905	3.85	3.07
1906	4.18	3.56
1907	4.33	3.87
1908	4.43	3.75

This shows an increase of Gas Sales in the ten years of 81 per cent. and in Electric Sales of 59 per cent. It will thus be seen that the sales of gas per capita has for these ten years at least outstripped the electric sales per capita. The price of each has been steadily decreased.

That there is still opportunity for growth in our business is indicated by the data given and the fact that although we have a population in this country estimated at ninety million, according to the best available returns only about thirty-six million are now served with gas, and there are only about five million customers reported by the companies. This gives a sale per meter of about $26. and a sale per capita of about 4300. Still beyond this we have the growth of business which should come from the natural increase of population which amounts to two or three per cent. per year.

It would thus appear that, contrary to the often heard rumor, the business is rapidly growing and the field is far from being fully occupied.

We occasionally hear that the water trust is absorbing all the water powers of the country and that the fast approaching failure of the coal supply will make us dependent upon them for our light and heat. The just published reports of the Government Geological Expert, however, estimate that but 4/10 of 1 per cent. of the original supply of coal has been exhausted.

In general it may be said that our business relations with the public and the authorities are becoming better. Matters not well understood are becoming better defined and the attitude of the public is improving as the conditions under which the companies operate are better understood through greater publicity, and there is decidedly less municipal agitation.

There have come up during the year several matters affecting our relations with the public.

In the New York Rate Case, confirmed by the Knoxville Water Case, and later in the Cedar Rapids Case, there appears to have been established the right of the government to regulate rates, from which there is no appeal unless by actual trial such rates have been demonstrated to have been so low as to be confiscatory, and the United States Supreme Court has indicated that in these cases at least, the Company is entitled

to receive at least 6 per cent. on its property above all proper charges.

In the New York Case the Court has allowed as a portion of the Company's property a valuation for franchise, and in discussing this point implies that if a State taxes a franchise it must allow the Company to collect from the rate payers the interest upon it.

The Court maintains that the attempt by Law to require certain pressures was unconstitutional because it could be accomplished only at great expense, and it permitted the valuation of the Company's plant to be based on reproductive value, which admitted the value due to increase on land and other property.

The new Federal Corporation Tax, which will go into effect on June 30, 1910, unless found unconstitutional by the Courts, affects all our companies. It imposes a tax of 1 per cent. per annum upon the net income of the company above $5000.

From the gross income can be deducted, beside the $5000., the necessary expenses of the maintenance and operation, including rentals and franchise payments, all losses not compensated for by insurance, reasonable depreciation, interest on an amount not exceeding the paid in capital stock, taxes and dividends received from other corporations subject to this tax.

If a Company, for instance, is capitalized at $6. per 1000 sold and earning 6 per cent. on its capital, the tax would be about one-third of a cent per 1000 sold.

In Massachusetts the sulphur allowance has been raised from 20 grains per hundred cubic feet to 30 grains per hundred cubic feet, subject to farther regulation by the Board of Gas & Electric Light Commissioners if deemed necessary.

I do not know why the decrease of our selling price cannot be taken as a measure of successful progress in solving the technical and engineering problems which must be solved to reach economical production.

It was not many years ago that a President of the Ameri-

can Association in an address devoted considerable time to a demonstration that gas could be produced and sold for one dollar per thousand, but gas is now being sold at much less than that in many large and medium size cities of the country.

As a measure of that progress and as probably representing the rate of decrease in the price throughout the country, it will be found that in Massachusetts the average price of gas was in 1887 $1.62, in 1897 $1.15 and in 1907 95 cents. Taking ten of the large cities of this country, it is found that prices for gas are 20 per cent. lower than fifteen years ago.

Regarding our selling price, the impression is general in the public mind that prices are lower in Great Britain than in this country and that we should be able to sell gas here as low as it is sold there.

In the recently published reports of the U. S. Geological Survey, it is stated that during the year 1908, 156,909,310,000 cu. ft. of artificial gas was sold in the United States for $133,511,122., or an average price of 85 cents.

It was difficult for me to find corresponding data for Great Britain. In Field's Analysis the average selling price of thirty-seven companies of large size is about 62 cents. The Board of Trade in their recent report state that in the United Kingdom there was 172,889,147,000 cu. ft. of gas sold by 771 companies, and the receipts were $146,129,275., or an average price of 84½ cents per 1000, but it is probable that the receipts as usual contained other things than gas, so the average price of gas may be lower.

I find in the Journal of *Gas Lighting* a statement by Mr. E. J. Slinn, Chairman of the Watford Company, "That there are something like 1250 gas undertakings in England and Wales and the average price of gas is 4 shillings (or 97 cents). The London price was 2s.9d. (or 67 cents)."

In our attempt to reach low prices we have, however, at the present time one serious handicap. There is invested in the United States over one billion dollars in gas properties, or a

capital of at least $6.37 per 1000 sold. The English Board of Trade returns show $3.26 capital per 1000 sold. This excess of capital per thousand is undoubtedly largely due to the higher cost of labor which enters so largely into the cost of all material and construction.

If 6 per cent. is a fair return on the investment, in either case, our selling price would necessarily be 18 cents higher, but this is not all, for if our capital is doubled, our taxes are increased several cents per thousand, which must go into the charge for gas.

Probably this larger capital per thousand is made necessary in part by our less densely populated cities and our smaller sales per capita. A large number of selected cities in the United States gave an average sales per capita of 5534 ft. The same number of cities of the same population in Great Britain gave a sales per capita of 8737 ft., or about 60 per cent. more.

If our engineers can produce a larger amount of gas per dollar expended on plant and our commercial men can bring about a greater sales per mile of main and per capita sufficient to reduce our capital per thousand to the English basis, the principal obstacle to prices equal to the lowest in Great Britain will be removed.

That we are making great progress in sales per capita is shown by the fact that thirty small and large cities, taken at random in the United States, show an increase in twenty years of from 1500 to 4500 per capita.

The Program.

We have endeavored in our program to make it broad in character and to deal with live matters. The Progress of the Industry—Matters of Public Policy—Illuminating Engineering—Chemistry—Oil and Oil Gas—Details of Plant and Apparatus—Retort House Results—Residuals—and several on Commercialism. Two of these interest me greatly.

A new field has been opened these past few years for the

use of one of our residuals, in the brushing, painting or sprinkling of roads with tar.

The traction of the automobile is totally different from that of the horse drawn vehicle, and roads which have stood the test of time and wear under the latter, fail quickly under the former traffic.

Particularly is this true if the usual method of keeping down dust, that of water, be employed. Each slight depression collects some of the water sprinkled upon it and remains wet longer than the slight elevations, with the result that in the depression the surface of the road is softer than elsewhere. The scouring action of the automobile wheel enlarges this depression. The watering and scouring is repeated till the road surface is worn into a multitude of little holes and the road requires resurfacing.

Water is about the worst thing than can be used upon roads of the present day. Something which will shed, not absorb water, is needed, that the softening action alluded to shall be avoided.

Oil directly and in emulsion is used with some success, but it has no binding action upon the road surface and often in wet weather becomes mixed with the road dust into a paste very disagreeable to pass over.

In tar we have both the binding and the water-resisting action. It has been used with great success, not only on the surface, but for binding together the first few inches below this, and I believe there will be developed a large market for our tar in this direction. When in one small state alone twenty million dollars worth of automobiles are engaged in wearing out roads, the extent of such a market is apparent. The matter will be fully dealt with in a paper and discussed by those who have given it careful study.

A most tantalizing will-o'-the-wisp has danced before our eyes for a number of years, rumors of yields and candlefect never dreamed of before have incited a few, mostly in New England, I believe, to redouble their efforts, to inquire

and experiment on the proper weight of charge, proper duration of charge, question of temperatures, and condition of gas in retort, mouthpiece, stand-pipe, hydraulic and take-off main. In fact, condensation beginning at the retort rather than at the point where writers on condensation usually begin.

A possible saving of rising three cents per thousand on cost of gas in the holder, while not equal to the saving to be had by the adoption of verticals, inclines or horizontals with machinery, is, with this exception, the largest possible saving in coal gas manufacture presented for our consideration for some time and therefore worthy of considerable attention.

In 20-ft. horizontals with charging machinery and 18 ft. inclines, the ordinary yield of 80 candle-feet from standard gas coal was easily pushed up to 85 candle-feet and held there —at times for considerable periods 90 ft. were obtained—under special circumstances 95 candle-feet would be reached—and once or twice 100 candle-feet was obtained—but like the cup of Tantalus, it was gone before we could enjoy its blessing.

That it is possible to produce 100 candle-feet or about 6 ft. of about 17 candle gas per pound of standard gas coal has been, however, demonstrated beyond question by months of continuous operation in a works managed by one of the most competent and conservative members of this Institute. These results will be presented for your consideration during the meeting. No more important economic matter has been recently brought before you and I trust it will receive your closest attention.

It is within the memory of many of us that a good-natured rivalry as to yield per pound among some New England men years ago ran the yield well up towards 6 ft. per pound. Candle-power was lost, however, and made up by the cheap oils then in the market. This yield was produced simply by increased heats, but the furnaces were of the old type, small in capacity, clinkered often, and while the average temperature by great exertion was maintained, yet the maximum and minimum temperatures were far apart.

From my own experiments and observation, I am of the opinion that while the filling of the retort, the duration of the charge, the variation of standard coals, the proper handling of the generated gas, the character of the material of the retort, the style of retort, whether vertical, inclined or horizontal, are all points to be cared for, they are minor points and the main thing is to apply a continuous, steady, even heat, probably not over 200 degrees higher than our good type furnaces yield us now; and this can be done readily if non-clinkering furnaces of sufficient capacity are installed, but such results cannot be produced by the ordinary furnace, since while its average temperature may be high enough, its maximum is too high, breaking up valuable compounds, while its minimum is not sufficiently high to produce the desired result.

The program is perhaps more crowded than it should have been, but it will give us a chance to make a trial of the sectional meeting which has been recommended by committees of the past.

We have arranged for the two halls of this building and are to hold some sessions in parallel. There are objections to this we know. The halls are not equally spacious and it is difficult to divide our work so as not to have some conflict, but the working time is barely twelve hours and either material must be cut out or so slurred over as to deprive it of its usefulness. Even with the double session, it will be necessary to closely abstract the papers and to concentrate ourselves upon the work. It is hoped not to restrict the discussions.

During the past year five of our members have passed from among us.

F. A. Persons, an Active Member, died Aug. 1, 1909.

C. A. Knight, an Active Member, died August 14, 1909.

O. P. Moon, an Associate Member, died October 26, 1908.

C. H. Jacobs, an Associate Member, died March 15, 1909.

D. A. Gildersleve, an Associate Member, died July 30, 1909.

All were men we were glad to have with us and whose loss we shall feel.

Few among us are able to do what Fred Persons did for this and other associations. Genial, always loyal, a host in himself, an untiring worker, he devoted his every moment at the meetings to doing those countless things, large and small which do so much to make the routine work of our meetings move smoothly along. His was the self-sacrificing spirit which sank personal matters for the good of the cause. His friends will long cherish his memory.

Mr. Gartley (in the chair): It is customary to refer the President's address to a committee who will report to the general body later. Presuming that this is your intention, without waiting for a motion to be made to that effect, I will appoint for this Committee, Messrs. E. C. Jones, of San Francisco; A. M. Barnes, of Cambridge, and C. C. Simpson, of New York.

The President: (Resuming the Chair). The next thing on our list is the report of the Nominating Committee, which is usually preceded by the appointment of tellers. I would ask to act as tellers during this meeting Mr. Geo. G. Ramsdell, of New York; Mr. A. L. Wilkinson, of Detroit, and Mr. W. R. Addicks, of New York.

The next thing in order is the report of the Nominating Committee, of which Mr. Randolph is Chairman.

Mr. Randolph: Mr. President and Gentlemen: Your Committee, appointed to nominate officers for the ensuing year, beg leave to report that, after due consideration, they unanimously nominate the following gentlemen:

For President, Wm. H. Bradley, of New York.

For First Vice President, R. B. Brown, of Milwaukee.

For Second Vice President, J. C. D. Clark, of Chicago.

For Secretary and Treasurer, A. B. Beadle, of New York.

For Directors, Donald McDonald, of Louisville, Ky.; I. C. Copley, of Aurora, Ill.; J. B. Klumpp, Philadelphia, Pa.;

John A. Britton, San Francisco, Cal., and Richard C. Congdon, Atlanta, Ga.

Respectfully submitted,
W. W. Randolph, Chairman.
E. G. Pratt,
R. M. Searle,
T. R. Beal,
W. F. Hart,
Nominating Committee.

The President: What action shall be taken on the report of the Nominating Committee? Unless there is objection to the report, a ballot is in order at once.

Mr. Williamson: I move that the Secretary cast the ballot of the Association for the names recommended by the Nominating Committee.

The motion was seconded, and carried.

The Secretary: Mr. President, I cast the ballot of the Association for the parties named in the Nominating Committee's report.

The President: Is Mr. Ramsdell present? (No response). Mr. Addicks, will you act as chairman of the tellers? And state the result of the ballot?

Mr. W. R. Addicks: I report that all the votes have been cast in favor of the nominees as read by the Chairman, to wit: W. H. Bradley for President, R. B. Brown for First Vice President, J. C. D. Clark for Second Vice President, A. B. Beadle for Secretary and Treasurer, and the following for Directors: Donald McDonald, of Louisville, I. C. Copley, J. B. Klumpp, J. A. Britton and R. C. Congdon.

The President: It gives me pleasure, gentlemen, to announce that the gentlemen nominated have been elected. I have no doubt you would all be very glad to hear from Mr. Bradley.

Mr. Bradley: Mr. President, and fellow members of the American Gas Institute. Several hundred miles of traveling

on a sleeping car without much sleep is not conducive to speech-making, but I wish to say that I thoroughly and heartily appreciate the honor you have conferred upon me. It is an honor to preside over an institution like ours, an institution which, by reason of its technical and scientific work, has achieved not only a national but an international reputation, composed as it is of the best type of American manhood, its members being those who think, act and work. The papers that will be read, and the discussions that will follow are of more interest to you than any remarks I might make. In conclusion, I will signify my acceptance of the office by saying that I will endeavor, to the best of my ability, to maintain the standard of excellence of the Institute on the high plane where it has been placed by those gentlemen who have preceded me. In doing this I shall ask the assistance of all the members, as well as the officers, and together we may succeed in advancing that standard beyond the position it now occupies. The pace has been set for us, and the course is open. Let us see that we come to the meeting of 1910 with a record of substantial progress in all relating to the good of the Institute and its members. (Great applause).

THE PRESIDENT: Gentlemen, it gives me great pleasure to introduce Mr. Brown—although he needs no introduction—and I want to say to you that the success of this meeting is very largely due to his efforts.

MR. R. B. BROWN: Mr. President and fellow members—I can only say that I highly appreciate the honor which you have extended to me. I shall do everything that lies within my power to second the efforts of President Bradley to keep the Institute going, if possible, at a better gait than it has gone in the past. I thank you. (Applause).

(There were cries of Clark, Clark!)

THE PRESIDENT: Is Mr. Clark present? (No response).

According to our Constitution and By-Laws the *Committee on Place of Next Meeting* should be announced at this time. However, it is customary for the presiding officer to confer

with the in-coming President, and, with your consent, we will delay that report until he has time to express his views upon that subject.

The next thing on our program is the report of the

COMMITTEE ON PUBLIC RELATIONS.

Mr. Lathrop is the Chairman.

MR. LATHROP: The report of the Committee is rather short. We have had a few meetings during the past year, but nothing of particular moment has been done. The report is as follows:

To the Board of Directors, The American Gas Institute, New York.

GENTLEMEN: This Committee has considered several matters during the past year bearing on public affairs, but its work has not been of such a nature that a detailed report is necessary.

One very important matter (STANDARDS—quality, pressure, etc.) has been under discussion, but data with which to work was received so late that nothing has been accomplished regarding it, and we recommend that it be taken up by the Committee to be appointed for the coming year.

Yours truly,

ALANSON P. LATHROP, Chairman.
J. L. RICHARDS,
E. G. COWDERY,
W. R. ADDICKS,
C. H. DICKEY,
WALTON CLARK,
Public Relations Committee.

THE PRESIDENT: What action will be taken on the Report of the Committee on Public Relations?

A motion was made, seconded and carried that the Report of the Committee be accepted.

THE PRESIDENT: Next is the

Report of the Technical Committee,

Mr. R. B. Brown, Chairman.

Mr. R. B. Brown: Mr. President and Gentlemen,—On behalf of the Technical Committee I will simply say that we have presented the list of papers which you find upon your program to the Board for acceptance, and we have a number of sub-committee' reports which we should like to call to your attention, all of which will be presented by the respective chairman of the committees.

The President: What action shall be taken upon the report of the Technical Committee?

The motion was made, seconded and carried that the report be accepted.

The President: We will now take up the Report on Electrolysis.

Mr. Brown: The report of the Committee on Electrolysis was submitted by Mr. Glasgow, Chairman, to Mr. Alfred Forstall for reading. We just hear that Mr. Forstall has not arrived, so I will ask the President to introduce Prof. Ganz, of Stevens Institute, who has acted as Consulting Engineer for this Committee. He will read the report.

The President: Gentlemen,—It gives me great pleasure to introduce to you Prof. Ganz, whom I think you all know.

Prof. Ganz: Mr. President and Members of the American Gas Institute,—At the request of the Committee on Electrolysis I have prepared a few notes, which I will abstract, because I understand that the time is limited. Two years ago I had the pleasure of delivering a lecture before the members of the Institute on the Methods of Conducting an Electrolysis Survey. I have had considerable experience since that time in applying these methods, and I find that, while the methods as given in my previous lecture had to be extended to meet special cases, particularly where it was necessary to determine which one of a number of current sources was affecting a given piping system, outside of that

the general methods as outlined in my previous paper cover the ground pretty well, and I will not at this time enter into the study of measurements at all.

I expect in this brief paper to deal with methods for protecting pipe lines from electrolysis, and the methods that may be applied can be grouped into two classes, the first class consisting of the introduction into the piping system of insulating pipe joints, so as to break up the electrical continuity of the piping system; and the second method consists in insulating the pipe from the ground.

In order to get all the information available on these points for the paper, with the authorization of the Committee I addressed a circular letter and a question blank to each member of the Gas Institute about 6 months ago, and I have received something like 200 replies. Many of the replies did not contain the information I really wanted, and in such cases I addressed a further question blank to the members, and in that way, by following up, I have the experiences from about 60 piping systems scattered all over the country. The data contained in these replies to my question blank have been abstracted, and these abstracts of the replies are given in an appendix to the paper. Names and locations are omitted, the abstracts referring merely to numbers, No. 1, No. 2, and so on.

REPORT OF THE COMMITTEE ON ELECTROLYSIS.

To the Chairman of the Technical Committee, American Gas Institute.

SIR:

REPORT ON ELECTOLYSIS.

The Committee on Electrolysis beg leave to report that they have arranged for their Consulting Electrical Engineer, Prof. Albert F. Ganz, to present to the American Gas Institute a memorandum on

designed to round up, as far as practicable, the views and work of your Committee.

The chief obstacle to effective progress which continues to face your Committee is the very reasonable objection, on the part of the various interests concerned, to making public the results of important current investigations; owing, in the first place, to the fact that present conclusions are of necessity of a more or less tentative character, and, secondly, to the fact that the present phases of these specific investigations are invariably of a confidential and generally delicate local character. These considerations have largely hampered Prof. Ganz in the preparation of his present memorandum, and have made it impossible for the Committee to secure other communications which they had anticipated would be at their disposal by this time.

Your Committee further beg leave to submit their opinion that no useful purpose will now be served by the continuance of a Standing Committee on Electrolysis. They consider it preferable, for the present at any rate, that the General Technical Committee should, as the opportunity offers, obtain communications from experts who are at the moment especially qualified to instruct or guide the members in some particular line of this work.

We, therefore, jointly and severally tender our resignations, together with our best thanks for the confidence that has been reposed in us.

Respectfully submitted,

John Williamson,
S. P. Curtis,
Arthur H. Hall,
Alfred E. Forstall,
J. D. Shattuck,
A. G. Glasgow.

Committee on Electrolysis.

NOTES ON PROTECTION OF UNDERGROUND PIPES FROM ELECTROLYSIS.

PREPARED AT THE REQUEST OF THE COMMITTEE ON ELECTROLYSIS FOR PRESENTATION AT THE ANNUAL MEETING OF THE AMERICAN GAS INSTITUTE, HELD IN DETROIT, OCTOBER, 1909.

By Albert F. Ganz, M. E.,

Professor of Electrical Engineering, Stevens Institute of Technology.

At the annual meeting of the Institute two years ago, I presented a brief paper in which general methods of making tests for stray electric currents on underground piping systems were discussed. Since then I have had considerable opportunity to use the methods described; while it has been found necessary to extend these methods and also to use a number of special methods to meet particular cases, especially for the purpose of identifying sources of stray current, the general plan outlined in my previous paper is sufficiently complete for ordinary requirements. I will, therefore, not discuss methods of testing in this paper, unless some member desires to ask questions on this point, in which case I will be very glad to answer.

I will consider measures for the protection of underground pipe lines from electrolytic corrosion where they are found to be endangered by stray railway currents. The natural solution is, of course, to remove the cause of the danger, that is, to get the railway companies to take care of their own currents. This is completely accomplished by the use of an insulated return circuit. Even without this, I believe that in almost every case where serious stray railway currents are found flowing on underground structures, it is possible to reduce such currents to small and oftentimes to negligible amounts by proper track bonding and by the installation of properly proportioned return feeders with the addition in some cases of negative boosters. The possibilities which can be accomplished

in this direction have only recently been appreciated in this country by railroad engineers. An excellent investigation of this subject is presented by Mr. George I. Rhodes in a paper entitled "Some Theoretical Notes on the Reduction of Earth Currents from Electric Railway Systems by Means of Negative Feeders," published in the *Transactions* of the American Institute of Electrical Engineers for 1907. This investigation clearly brings out the great reduction of stray currents which can be accomplished by insulating the negative bus-bar at the power-station and running out properly proportioned insulated return feeders to various points in the track net work. This is in fact the plan which has already been very successfully carried out in Europe, and which was described in the Report of the Committee on Electrolysis presented to the Institute in 1906. I am informed on excellent authority that in two American cities the installation of properly proportioned radiating return feeders as referred to above has reduced the stray currents on the piping systems to less than one-tenth of its former value. In some cases where a road owns its own private right of way, it is perfectly practicable to substantially insulate the rail return circuit and thus eliminate serious stray currents.

If the underground piping system is a continuous electrical conductor of low resistance, and is affected only by currents from known sources, then it may be protected by metallically connecting it to the negative return circuit of each source. Such a bonding method, however, greatly increases the current flow on the system and produces other dangers, as, for instance, at a high resistance point, which may develop in a joint; here the current may shunt around such a high resistance point and produce corrosion. The greatest objection, however, lies in the danger that such a bonded system constitutes to all other underground metal systems. If we connect one piping system to the negative bus-bar we render it highly negative to all other underground metallic structures and induce current to flow to this piping system, thereby increasing the

electrolytic dangers to other systems and producing also other dangers such as a fire hazard from sparks or arcs; such a bonded piping system becomes in fact, a part of the trolley return circuit, and the owner becomes a party to any damage that may result in the other underground systems. I have myself found various cases where actual danger and damage was caused to one underground system by the bonding of a second system. I know of one case where a large piping system was bonded to the negative return circuit of the railway by heavy copper cables in order to protect it from electrolysis. Serious trouble arose, however, from arcs produced by the large currents carried on the pipes, and explosions and fires resulted, in one case also severely burning a mechanic who was making repairs to the pipes. After two years of trial all bonds were removed as the dangers produced by them were considered more serious than the possible protection from electrolysis afforded. I firmly believe that only such methods should be used which substantially prevent stray currents from flowing to and from the underground structures.

In regard to means which can be applied to piping systems to rid them from stray railway currents, there are two possibilities to be considered and which have been tried, namely, insulating pipe joints and insulating pipe coverings. I have had some experience with and have made some tests in regard to each one of these methods. In order, however, to collect the experience from as many sources as possible, I addressed a circular letter and question blank several months ago to each member of the Institute, with the authorization of the Committee on Electrolysis, asking for his experience especially with reference to the above means for the protection of pipe lines.

In all 1308 question blanks were sent out and 138 replies were received. Of these, 74 do not give any useful information, while the remaining 64 replies answer some or all of the questions, or give other definite information. I have made a careful study of the replies as received, and where the answers given did not enable me to get all of the information desired.

I have endeavored to get this by further correspondence. A number of the members were good enough to furnish me me with copies of electrolysis surveys made upon their systems, and I have also studied these in connection with the answers furnished. In this way I have collected the experiences with about 60 piping systems located in 32 different states scattered all over the United States. I have prepared extracts giving the important facts of such answers as describe characteristic conditions, and these are tabulated in an Appendix under three headings: Experience with Cement Joints, Experience with Insulating Joints, and Experience with Insulating Coverings. The replies are arbitrarily numbered, and the extracts refer to these numbers, no names or localities being given.

Discussion of Experiences With Cement Joints.

Thirty-nine replies report experiences with cement-jointed mains in the vicinity of electric trolley roads. Thirteen of these replies state that no trouble whatever from electrolysis has been found. In most of these cases, however, no actual tests have been made, the statement being merely based on general experience. Seven replies report some electrolytic corrosion of the cast-iron mains; one of these reports corrosion at joints and the complete destruction of the structure of the cast-iron. One other reply reports signs of pittings near the joints at a number of points. In twenty replies the electrolytic destruction of service pipes from cement-jointed mains is reported, and in some of these cases this trouble is said to be very severe.

I have examined two systems in which services from cement-jointed mains have been destroyed. It was found that the destruction had been caused by electrolysis from stray railway currents and that these currents had reached the gas service pipes from the water mains through house service connections. That is, current was found entering by the water service pipe from the water main, reaching the gas service through the house piping, and leaving the gas service pipe through ground

to return to the railway tracks, and producing corresponding electrolytic destruction of the gas service pipe. Tests also showed that the water main, which was laid with lead joints, in these instances, was carrying large stray railway current, while no measurable current could be found flowing on the cement-jointed gas mains.

I want to report one case of damage relating to a lead-jointed gas main, where current was also found entering a building from the water main through a water service pipe, and leaving the building through the gas service pipe. The existence of this current on the gas service pipe was discovered when a meter was to be replaced, by the production of a severe arc when the gas service pipe was disconnected. An examination showed that current entered by the water service pipe and reached the gas service pipe through contacts with a metal ceiling. This current was very large, reaching maximum values of 16 amperes. This condition was found in a district where the gas piping is highly negative to the railway return conductors, the current from the gas service flowing to the gas main, and passing along the gas main to leave it at some other point. Electrical tests indicated that the water piping system was in metallic contact with the railway return conductors. This is an example of a distinct fire hazard produced by stray railway current entering and leaving a building through service pipes, and I have found similar cases elsewhere. This same dangerous condition is in fact likely to occur wherever services from two piping systems enter a building, of which one system is bonded to the return circuit of the electric railway.

In order to obtain the approximate electrical resistance of cement joints, I have measured the resistance of a large number of joints on different sizes of mains in actual use. The resistance values found vary from a fraction of an ohm to several hundred ohms, the majority of joints showing high resistance values.

Two cement joints on eight-inch cast-iron pipes were also subjected to tests in the laboratory of Stevens Institute. These

joints were tested for resistance after having been made up for several months with currents varying from 0.02 ampere to 5 ampere. One of these joints showed a practically constant resistance of about 40 ohms. The second joint showed a variable resistance for different current strengths; with 0.02 ampere the resistance was 28 ohms, with 1 ampere it was 4 ohms, and with 5 amperes it was only 0.7 ohm. This phenomena of variable resistance with different currents is characteristic of imperfect contacts. It is therefore likely that in the cement joint showing the variable resistance the end of the spigot is in mechanical contact with the interior of the bell, but forming an imperfect electrical contact, while in the first joint showing a constant resistance the end of the spigot and the interior of the bell are out of contact altogether. Six additional cement joints on 8-inch cast-iron pipes were also subjected to laboratory tests after having been made up for about a month. Three of these joints showed low resistances varying from 0.01 to 0.05 ohm, while the remaining three joints showed resistances varying from 5 to 10 ohms. Each of these 6 joints showed some variation in resistance for different current strengths, but these variations were not large. It appears that in the three joints showing low resistance the pipes must be in metallic contact, while in the three joints showing high resistance there is no metallic contact. It is probable that the resistance of these cement joints will increase with age. All of the cement joints tested except those which show such low resistance values as would indicate metallic contact, showed a polarization voltage varying from 1.5 volts immediately after the current was removed to about 0.1 volt after twenty-four hours; this means that a voltmeter connected across one of these joints gives an indication after the current had been interrupted. While this polarization voltage cannot produce any substantial current flow, its existence is nevertheless significant and may give rise to misleading conclusions from tests upon cement-jointed mains. As an example of this I would cite an experience which I had about a year ago. On a cement-jointed main no readable deflection could be obtained on a sensitive

millivoltmeter in 11 feet of continuous pipe. Across one cement joint a potential difference of 0.22 volt was indicated, however, and across the adjacent cement joint a potential difference of 0.13 volt, while across both joints the potential difference was nearly 0.4 volt. The measurement of the potential difference over 750 feet of this main, including about 60 cement joints, gave a value of 0.5 volt; but an ammeter connected across these two points by copper wires did not indicate any measurable current. It is therefore clear that this main, although showing substantial potential differences across individual joints, was not carrying any measurable electric current.

So far as being effective in breaking up the electrical continuity of a pipe line laid with all cement joints, it does not matter whether the joints have a resistance of a few ohms or of thousands of ohms; considering that the resistance of cast-iron pipe is only a few hundred-thousandths of an ohm per foot of length, it will be seen that compared with the pipe itself, the resistance of a cement joint is generally so high that it may be classed with insulating joints. It follows, therefore, that a pipe line laid with all cement joints has such a high electrical resistance that with the potential differences ordinarily found in the ground no measurable current can flow along such a pipe line. Numerous tests made by myself confirm this. An interesting and valuable test is also reported in one of the replies. A cement-jointed cast-iron main paralleling a trolley track was metallically connected to the track at its two ends with an ammeter inserted in one of the connecting wires. No measurable current was indicated on the ammeter. In this same system the cement-jointed mains are connected to the return circuit of the railway at the substation. An ammeter was connected in this bond wire but no current flow could be detected. Similar results were obtained in a series of tests made upon a cement-jointed water main in Los Angeles, Cal., and reported by E. F. Scattergood in a paper published in the Sibley Journal of Mechanical Engineering for March, 1905.

Bond connections from cement-jointed mains to the return-circuit of electric railways as reported in a number of the replies, can therefore protect only that single length of pipe and the services connected to that one length of pipe to which the bond wire is connected, but cannot possibly serve to protect the piping system.

Discussion of Experiences with Insulating Joints.

Nineteen replies report experiences with special forms of insulating joints, and extracts from fourteen of these are given in the appendix. Most of the pipe lines where the use of insulating joints is reported are individual high-pressure lines to which no service pipes are connected.

In four of these pipe lines every coupling is made an insulating joint, and it is reported that they do not carry stray currents, and that there is no trouble from electrolysis.

In twelve of these pipes a comparatively small number of insulating joints are used, variously spaced depending upon local conditions, and it is also reported that there is no trouble from electrolysis. Most of these lines have, however, been in service for an insufficient time to warrant the conclusion that no electrolytic action is going on.

In two high-pressure lines where insulating joints were spaced five hundred feet apart, serious electrolytic damage resulted, and it is reported that these pipe lines have since been connected to the negative return of the railway, and the insulating joints bonded over by copper cables, thus eliminating the insulating feature of the couplings.

A wrought-iron pipe line paralleling a poorly constructed trolley road for thirty-four miles, with three power-houses located along the line and with Dresser expansion sleeves located every half mile, is reported to have suffered from electrolysis in the neighborhood of the power-houses.

In one reply it is reported that an entire city gas supply system is laid with wrought-iron pipe with nearly all of the couplings insulated joints, and that after six years of service no trouble from electrolysis has developed.

I have also had occasion to test one high-pressure wrought-iron main laid with all Dresser joints several miles long and paralleling and running close under trolley tracks for a considerable distance. This main did not show any measurable flow of current and a temporary copper wire connection with an ammeter in series between the pipe and the rails at a number of points did not produce any flow of current. This pipe line has been in service for over five years and so far has given no trouble from electrolysis.

Discussion of Experiences with Insulating Pipe Coverings.

Sixteen replies report experiences with insulating pipe coverings, and all but two of these refer to service pipes.

One of the two mains provided with an insulating covering is a 2-inch high-pressure line one mile long, and connected at one end to a gas works, and at the other end to holders. This pipe was boxed and filled with pitch, but electrolytic trouble developed at several points, at some of which the covering was found to be defective. By breaking up the line into insulated sections by insulating joints, in addition to the covering, the trouble is stated to have been overcome. The second main is also a high-pressure line, of 3-inch wrought-iron pipe. The attempt to protect this by boxing it and filling with concrete failed. A portion of this line which was boxed and filled with two inches of pitch also developed electrolytic trouble at a few points, but it is stated that at these points the covering was found mechanically damaged. Examination of the pipe under good coating of pitch showed the pipe to be bright and without signs of corrosion.

Five of the service pipes protected by coverings were painted with some form of compound, usually containing tar. These coatings are found to prolong the life of the services but do not generally prevent electrolysis.

Five services were boxed and filled with pitch, which proved effective in four cases but failed in one case. Four services are reported boxed and covered with cement or concrete and

this appears to have prolonged the life but has not prevented electrolysis.

In regard to cement or concrete as a protection from electrolysis, I know of one case where an 8-inch pipe was boxed, leaving from four to five inches between pipe and box, and this space was filled with concrete; this main was in a location where currents were leaving the main, and where previously there had been considerable electrolytic action. It was found that the corrosion went on at least as rapidly with the main imbedded in concrete as before, and the main was destroyed in a comparatively short time. When the box was broken open, the iron pipe was found to be very badly corroded and pitted, and the rust had penetrated more than an inch into the concrete.

Investigations made by Knudson[1] and by Langsdorf[2] also show that iron and steel imbedded in concrete will be corroded by electric currents passing from the iron or steel through the concrete.

I have had occasion to examine a steel main which had been dipped in a tar pitch compound before being laid, and which had been in service for about five years. The coating in most places was found to be apparently intact and firmly attached to the steel, and varying from about 1/32 to 1/8 of an inch in thickness. At other places the coating appeared cracked and was brittle, or was entirely removed for considerable areas. In a locality where the main was lying in a marsh and was subject to electrolysis from stray currents, deep pittings were found in the steel under apparently good heavy coating, which in some cases had to be scraped away with considerable force. Electrolysis appears, in this case, to have gone on under an apparently perfect insulating coating.

In reply to my question blank Mr. Robert B. Harper, Chief Chemist of the Peoples Gas Light and Coke Co. of Chicago, kindly sent me a copy of a paper on "The Comparative

[1] "Electrolytic Corrosion of Iron and Steel in Concrete". By A. A. Knudson, Transactions of American Institute of Electric 1 Engineers, 1907.

[2] "Electrolysis of Reinforced Concrete". By A. S. Langsdorf, Journal of the Association of Engineering Society, February, 1909.

Values of Various Coatings and Coverings for the Prevention of Soil and Electrolytic Corrosion of Iron Pipe." This paper was read by Mr. Harper before the Illinois Gas Association on March 18, 1909, and contains the results of an exhaustive investigation of a large number of commercial pipe coatings and coverings. The results given are of great value in the study of the problem of pipe protection. The conclusions drawn by Mr. Harper are so to the point and agree so well with my own experience that I will quote them in full in the following:

1. "That paints as a rule do not prevent electrolysis, but some, no doubt, have a beneficial effect in curtailing soil corrosion.

2. "That the appearance to the naked eye of a paint film is no indication of its permeability to water.

3. "That corrosion of metal may take place beneath a paint film without apparently affecting the appearance of same.

4. "That the metallic body before being covered, must be smooth and free from rust, moisture, loose scale and foreign matter in order that it be preserved.

5. "That, in general, dips applied hot are better than paints and probably furnish the key to the solution of the prevention of corrosion.

6. "That concrete of itself is not an efficient protection against electrolysis.

7. "That ingredients such as rubber, tallow, lime, etc., usually have a deleterious effect upon the efficiencies of coal tar pitch."

Mr. Harper's paper has been published in full in the issues of the American Gas Light Journal from August 9 to September 13, 1909, inclusive.

Summary and Conclusions.

The statement that a given piping system is not suffering from electrolysis cannot always be taken as evidence that the

system is actually free from stray currents and is immune from electrolysis, and especially not when reference is made to cast iron mains carrying gas at ordinary pressures. The effect of electrolytic corrosion of cast iron is to oxidize the iron, leaving the iron oxide and the graphitic carbon in place whereby the form of the pipe is kept intact. I have seen cast iron pipe which was apparently in good condition and carrying gas without leaking, which upon being tested with a hammer was found to be pitted entirely through the iron in more than one place. I have seen such cases where the blow of a hammer caused a plug as large as a silver dollar, of this graphitic remains from electrolysis, to drop out exposing a hole through the pipe. Some of the replies which report that there is no trouble from electrolysis and where no proper examination has been made, therefore, do not afford conclusive evidence of immunity from electrolysis.

Cement joints as ordinarily made do not generally produce metallic electrical connection between the two pipes and such joints may practically be classed with insulating joints. A pipe line laid with all cement joints or with insulating joints is therefore a discontinuous electrical conductor and is not capable of carrying stray electric currents. Such a pipe line cannot, therefore, pick up current in an extensive negative area to discharge it in a restricted positive area, which is generally the cause of the most serious electrolytic danger. For this reason a piping system with all cement or insulating joints is on the whole much less likely to be affected by electrolysis than a piping system with all lead joints or with screw couplings. Experience has shown, however, that a cement-jointed piping system is by no means immune from electrolysis, and we have abundant reports which show that cement-jointed mains and especially service pipes from such mains can suffer severely from electrolysis. In these cases the stray currents reach the mains and service pipes from other pipes or by other paths. Where the current which reaches a service pipe connected to a cement-jointed main can be definitely traced as coming

from house services, it is possible to stop this flow of current by introducing an insulating coupling in the service pipe inside of the building or in the riser connecting to this service pipe. It is also conceivable that a pipe may lie in ground in the path of earth currents of sufficient density to produce electrolytic action upon the pipes. Such a high density of earth currents may exist in the immediate vicinity of electric railway power stations having a poorly constructed return circuit. A reasonably good construction of the return circuit of the railroad should, however, prevent the existence of any such dangerous current density in the ground, as such current would be clearly a source of very great danger to all underground metal lying in its path, including steel building foundations.

The question of whether a pipe line can be protected from electrolysis by installing a limited number of scattered cement or insulating joints depends entirely upon local conditions. There are undoubtedly cases where the installation of even a few insulating joints at proper places will greatly reduce if not eliminate electrolytic danger. Experience has shown, however, that a few individual insulating joints may do more harm than good, and they can only be applied in special cases and then only at points where electrical tests have indicated that they will do good.

As to the cause of the high resistance of cement joints, this is probably due to the fact that although in laying cast iron pipe every attempt is made to push the spigot end home into the bell, as a matter of fact in most cases the two pipes are not in metallic contact. Even where there is metallic contact this is probably over a comparatively small area, if not at a point; as the end of the spigot is always heavily coated with scale, such metallic contact generally forms a poor electrical contact of comparatively high electrical resistance. It is a simple matter to positively prevent metallic contact by inserting a ring of some cheap insulating material such as fibre or cardboard between the end of the spigot and the interior of the bell, and

this has been done in some cases. The resistance of cement joints is then the electrical resistance of the cement intervening between the spigot and bell, and while cement is not an insulator but on the contrary is probably as good a conductor as ordinary ground, yet compared with iron the resistance is so high that the cement joints practically interrupt the electrical continuity of the pipe line.

In the case of lead joints, I have had occasion to measure the resistance of several hundred joints in use on various sizes of pipes. These joints generally have a comparatively low resistance, being equivalent as a rule to the resistance of ten or twenty feet of continuous pipe. Occasionally, however, I have found lead joints which have resistances equal almost to one ohm and equivalent to over 10,000 feet of continuous pipe. I have made special tests in the laboratory of Stevens Institute upon two cast-lead joints and upon two lead-wool joints made on 8-inch cast-iron pipes. These joints were made in every respect as they are made in practice and without taking any special precautions, and the resistance tests were made a couple months after the joints had been calked. The resistances found were as follows: 0.0002 ohm for the first cast-lead joint, 0.00006 ohm for the second cast-lead joint, and 0.00003 ohm for each of the two lead-wool joints. The resistance of the lead-wool joints appears, therefore, to be about half of that of the lowest resistance cast-lead joint. The resistance of a lead joint is almost entirely that of the surface contact between the lead and the iron. The lower resistance of the lead-wool joint is, therefore, probably due to the fact that the lead of the joint makes contact with the iron over a greater area than in the case of the cast-lead joint. Since the resistance of a lead joint is that due to the surface contact it is clear that such joints are likely to increase in resistance with age, and this appears to be borne out in practice. I remember testing one lead joint in a very old pipe which gave a value of about 0.4 ohm. By standing on one of the pipes the resistance was reduced to one-tenth of its former value due probably to

the fact that under the strain better surface contact was made between the lead and the iron.

Where a cast-iron lead-jointed main has been in the ground for a great many years, it is probable that many of the joints have reached such high resistance values as to effectively break up the electrical continuity of the pipe. I have also found that very old pipe, especially early pipe that was imported from Scotland, is coated with a surface scale or oxide which has such a high surface resistance as to be practically an insulating covering. I have found cases where it was necessary to apply chisel and hammer and cut through a thick and very hard coating before electrical contact to the iron could be made. Where such old pipes were in the ground before electric traction was started they are very much less subject to trouble from electrolysis than new pipe, affected immediately by stray current, the effect of the electrolysis being to produce a condition around the pipe which aids corrosion and prevents the formation of a self-protecting insulating covering.

In regard to the use of insulating pipe coverings, experience shows that embedding a pipe in cement or concrete, even if this is several inches in thickness, does not protect the pipe from electrolysis, and in some cases it has even been found that the pipe in concrete is destroyed at least as rapidly as when it is buried in ground.

As to the use of paints or dips for protecting pipes, the first difficulty is the mechanical one of applying the paint so as to form an absolutely perfect coating, and then to prevent mechanical damage to the coating. Where imperfections exist or develop aggravated trouble always ensues. Experience further seems to show that even where paints or dips are apparently intact and perfect, electrolytic action is not prevented, and in fact very serious electrolytic pittings have been found under apparently good coatings.

The only kind of insulating covering which appears to afford certain protection is a layer of at least one or two inches of a material like coal tar pitch or asphaltum, of such a grade

that it is not brittle and so will not crack, but yet is hard enough to remain in place. The best way to apply such layer is to surround the pipe with a wooden box, support the pipe upon creosoted blocks of wood or upon blocks of glass, and then fill the space between the box and pipe with the molten material. As a further protection an insulated coupling should be introduced at each end of the section covered so that even if the covering should become defective at any point or points no current can reach these points to corrode them by electrolysis. A pipe treated in this way with the work done so as to be mechanically perfect would undoubtedly be protected from electrolysis. However, the cost of carrying out such an installation is absolutely prohibitive, except in a few cases, such as in the case of service pipes in very bad localities or in the case of some very important individual pipe lines of small size. It is not sufficient to apply the covering only in the positive district, nor, on the other hand, is it always necessary to cover the entire length of line. The portions which must be insulated can only be determined by properly conducted electrical tests.

Regarding the use and value of an electrolysis survey, it must be remembered that the object of the survey is to indicate the existence or non-existence of stray electric currents upon a piping system, and to determine where such currents flow on to the pipes and from the pipes. I have had occasion to examine a large number of electrolysis surveys some of which were kindly loaned to me by members in reply to my question blank. Most of these surveys consist, however, exclusively of voltmeter readings. Such readings by themselves do not afford a measure of electrolytic danger; they merely indicate where the greatest danger is likely to exist. Measurements of current flow on pipes are essential in an electrolysis survey because all current which flows on a pipe must leave it, and the amount of damage produced is proportional to the total current which leaves the pipe. I have seen some reports on the other hand, where it is stated that

the current on a given pipe is zero, but where the instruments and methods employed were not sufficiently sensitive to detect currents as large as two or three amperes, and where, therefore, the conclusion of zero current is not warranted. From a complete and properly analyzed electrolysis survey, a great deal of good can generally be accomplished. It will not always be possible to remove all stray currents from the pipes, but measures will be indicated by which the conditions can be greatly improved, and points of greatest danger will be located. If then trouble does occur at a later time at these points, the electrolysis survey may be most valuable in affording proof of the destruction of the property from railway currents and may be the means of compelling the railroad company not only to pay for the damage but also to make improvements in its return system so as to avoid the recurrence of such damage. I know of a number of electric railroad companies who are regularly paying for damage caused by electrolysis to piping systems. The knowledge that a pipe owning company is making electrolysis tests and is keeping watch on the situation, also has a strong moral effect on the electric railroads.

In conclusion, I wish to say that I have no doubt some of the members will be disappointed in my paper because I have not been able to present a simple cure-all for electrolysis. I am afraid that the only possible cure-all is an insulated railway return system. I am convinced, however, that in nearly every case where serious stray railway currents flow on piping systems a very great reduction of these currents can be accomplished by improvements in the return circuit of the railways, and in many cases these stray currents can be reduced to a small fraction of their former amount, and this should in every case be the first step. After this has been done there are many cases where insulating methods judiciously applied to the piping system will further greatly reduce the stray currents which still remain.

I wish to take this opportunity to thank the members of

the Institute who were good enough to furnish me with data and information for this paper.

APPENDIX.

Extracts Quoting Experience with Cement Joints.

Reply No. 3. Practically all joints were made of cement until about 1882. For several years the rule has been two cement joints to one lead joint. The mains extend parallel to trolley tracks and close to power-houses. Most of the trouble has been local to power-houses. In the worst cases the pipes were badly pitted. The plumbago condition is more wide spread than the pitting.

Reply No. 8. Practically all the mains are cast-iron with cement joints. Trolley tracks in most cases are within ten feet of mains. Power-house is 200 feet from nearest main. No electrolysis tests have been made but mains are examined for electrolysis each time they are uncovered. There has been considerable trouble from electrolysis of service pipes, the trouble being throughout city on streets having trolley lines.

Reply No. 10. Two miles of cement-jointed mains with every fifth joint lead have been in service five years. Mains lie directly under trolley tracks. Power-house is five miles away. So far there has been no apparent trouble with mains, but trouble with service pipes.

Reply No. 12. Practically all suburban mains have been laid with cement joints for about five years. Many of the pipe lines are parallel to trolley tracks and some are near sub-stations. Accurate tests show that no current flows along the lines of the mains. There has been one case of electrolytic action on cement-jointed main at a point close to the power-house. There has been trouble from electrolysis of service pipes, principally in the vicinity of railroad sub-stations. The mains are generally bonded to the negative returns of the neighboring power-houses or sub-stations. Tests show that the bond connections from cement-jointed mains do not return any measurable current.

Reply No. 13. 1,500 feet of 6-inch cast-iron mains were laid with cement joints eleven years ago. Main lies near power-house, and services have been eaten out in the past. The mains were covered some two years ago by a stone and cement paving and at this time nearly all of the services were renewed and boxed in tar or pitch. The tracks were also put in the best of condition. Tests fail to show any currents wandering from water pipes through house piping and back to the gas services.

Reply No. 14. Many miles of cast-iron mains with cement joints have been laid since 1900 in all parts of the city near power-houses, crossing trolley lines and paralleling them. So far no corrosion of these mains has been found but some little evidence of electrolysis upon services connected to these mains has been found.

Reply No. 16. All street mains have been laid with cement joints and no special care has been taken to prevent metallic contact between the sections, though apparently the cement joints do break up the conductivity of the pipe, as in some cases there is evidence of current jumping around a cement joint. The ordinary distance between joints is twelve feet, and there are lines along the sides, crossing and entirely away from the trolley tracks. There has been trouble with corrosion, pitting, and complete destruction of the structure of the cast-iron in pipes along the side of trolley lines. In all cases, however, it was found that the current apparently was flowing from the rails to the pipe and from the pipe to other structures. The most serious trouble was found on one street, which is a trunk line of railway.

Reply No. 18. 500 feet of cement-jointed cast-iron main has been eight years in service and parallels trolley tracks five feet distance. Pipes were shoved home when being laid. There is no power-house nearby. No tests have been made and no trouble from electrolysis has been found.

Reply No. 19. Practically entire system consisting of about 100 miles consists of cast-iron pipes laid with all cement joints.

Pipes were shoved home when being laid. Some of the lines have been in service for over forty years. Some lines are in same street with and close to trolley lines and to power-house. No evidence of corrosion has been found except in one place and that within a few blocks of power-house and pitting at this point was not serious.

Reply No. 20. Forty-six miles of cement-jointed cast-iron mains have been in use from one to fifty years. The pipes are nearly always in metallic contact inside the joints. Trolley tracks parallel with pipe in many streets and power-house is within thirty feet of one of the mains. No tests have been made and no corrosion or pitting has been noticed.

Reply No. 22. We commenced laying cement joints in about 1895, and mains are now laid with all cement joints in which the pipes are in metallic contact. There has been no trouble from corrosion or pitting in mains, but a few cases of electrolysis in services have been found.

Reply No. 23. Cement joints are used on some of the lines but no attempt was made in laying them to make them insulating. In one case about 2,500 feet of 8-inch main with cement joints lie on an average within three feet of trolley rails. Power-house is two miles away. This line has been in service fifteen years, and shows signs of pittings near the joints at a number of points. Tests show some flow of current all along the lines for at least two miles from power-house, and considerable damage has been found.

Reply No. 24. A 6-inch main laid in 9-foot lengths, all cement joints, was abandoned, after having been in use for thirty years. This main laid in the central part of a large city and under trolley tracks. Wherever this pipe was exposed or it paid to take it out it was found in perfect condition.

Reply No. 25. All mains are laid with cement joints and these have been in use from one to thirty years. Electrolytic destruction of service pipes has been found. Tests show that current flows on the service pipes from water mains through water service connections. Trouble was stopped by intro-

ducing insulating joints in these service pipes and also by covering each service pipe by a discarded larger cast-iron pipe metallically connected to the service pipe.

Reply No. 27. All cast-iron mains are laid with cement joints and are in metallic contact inside of joints. Trolley tracks are on a great many streets distant two to ten feet from pipes. There has been some trouble with supply pipes near power-house, but no tests have been made.

Reply No. 30. Some lines with cement joints have been in use for twenty-five years or more. The pipes were apparently laid without any thought as to metallic contact inside of the joints. No tests have been made and no apparent trouble from electrolysis has been found.

Reply No. 31. One and one-half miles of cement-jointed cast-iron pipe have been in service six and one-half years. The pipes are supposed to be in metallic contact. About one-half mile of pipe line is from three to five feet from trolley tracks; end of line is about three-quarters mile from trolley power-house. No tests have been made and no trouble from electrolysis has been noticed.

Reply No. 34. Nearly all pipes have been laid with cement joints since the works were started in 1853. Spigot end is driven home. A very thorough electrical survey of the conditions of the pipes have been made in unison with the city water system and the electric car system. The results of the survey are that the pipes were practically free from electrolysis. Some trouble was developed in the city water system.

Reply No. 35. Cement-jointed mains are in use, and the pipes are in metallic contact inside of the joints. Trolley tracks are on streets with pipes and about four feet from pipes; power-house is on same street. Some shallow pittings have been found in front of car barns and power house. There has been considerable trouble from destruction by electrolysis of the wrought-iron service pipes. No remedy has been found to stop this.

Reply No. 36. Practically all mains are laid with cement joints driven home in sockets as far as possible before cementing, thereby making iron to iron contact. One mile parallels trolley tracks. No tests have been made and no trouble from electrolysis has been found.

Reply No. 38. One-quarter mile of cast-iron cement-jointed mains have been in service four years. Pipes are in metallic contact. Trolley tracks are within eight feet and power-house is 4,000 feet away. No tests have been made and no trouble from electrolysis has been found.

Reply No. 39. Several cast-iron pipe lines are laid with cement joints. Joints are so made as to form a metallic contact through joints. One and one-half miles of 16-inch pipe have been in service forty-seven years. Trolley line has operated on this street for past three years. Location of nearest trolley power-house is about one mile distant. This main carries very little current and lies in a negative district in regard to the electric car system. There has been no apparent trouble from corrosion or pitting on main. There has been trouble with services being eaten out. Trouble caused by poor construction of electric lighting system and this trouble was localized in a district about four blocks long. Trouble does not seem to have any relation to trolley power-house district. The trouble disappeared when the Electric Lighting Company repaired its line.

Reply No. 40. Cement-jointed mains are in use. Pipe line parallels and frequently crosses under trolley tracks. No pitting of cast-iron pipe has been found. Wrought-iron pipes are badly pitted in some localities where street railway bonding was in bad shape. Trouble noticed more particularly in the immediate vicinity of street railway tracks. No tests have been made.

Reply No. 41. We have 1200 feet of cast-iron mains laid with cement joints with metallic contact inside of joints. Every fifth joint in lead and mains have been in service twenty-five years. Mains are inside of loop where trolley cars are con-

stantly passing, and are not near power-house. There has been some trouble from electrolysis at one point where the mains come close to the surface directly under the rails. No tests have been made.

Reply No. 43. About 310 miles of cast-iron mains with cement joints ranging in size from three inches to twelve inches have been in service from one to fifty years. Mains are laid with all Roman cement joints. Mains are in all streets where there are trolley tracks, about six feet distant. Mains also cross under trolley tracks. During the last six years about twenty-five services have been corroded by electrolysis. It is believed that in some cases this current was conveyed from the water service pipes to the gas service pipes, also in some cases from telephone and electric ducts to gas services rather than from the gas mains. Most trouble was found near switches and joints of rails. Pipes were usually affected directly under rails and about two feet on either side of rails.

Reply No. 44. Miles of mains with cement joints laid with pipes iron to iron has been in service from one to six years. Mains parallel tracks at an average distance of six feet and frequently cross the tracks. Power-house is from one to nine miles from gas mains. There has been no trouble from electrolysis.

Reply No. 45. Sixty miles of cast-iron mains are laid with all cement joints. In most cases they are made in such a way as to have a metallic contact inside of the joints. Some tests made show that mains are carrying very small stray current. No trouble from electrolysis has been experienced.

Reply No. 48. About forty per cent. of the cement-jointed gas mains are in streets parallel with and quite close to trolley tracks and a small portion of them are near the trolley power-house. All joints are supposed to have metallic contact inside by being put home before joint is made. Pipe lines near trolley power-house were found to be carrying stray current but thus far no damage from these mains has been discovered. Trouble with electrolytic corrosion of ser-

vices in the vicinity of the power-house and also near the local car barn has been experienced. Services have been destroyed where they cross over bare return wires lying in the ground near the trolley power-house.

Reply No. 49. We have several miles of cement-jointed mains not made in metallic contact mostly away from trolley tracks; probably two miles of mains are in streets with trolley tracks. Some traces of electrolysis on mains have been found. Tests have shown trouble to have been caused by poor bonding of trolley road and when this bonding was repaired the trouble ceased.

Reply No. 50. Two miles of cement-jointed cast-iron mains have been in service ten years. Mains lie eight feet from trolley tracks and trolley power-house is several miles away. There has been no trouble from electrolysis of mains but trouble from electrolysis of services. No tests have been made.

Reply No. 42. All mains consisting of a great many miles are laid with cement joints and have been in use for a great many years. Pipes are probably not in metallic contact in most cases. Tests show that these mains do not carry any current. There has been no trouble from electrolysis of mains but two or three scattered services have been destroyed by electrolysis.

Reply No. 51. All mains are laid with cement joints and have been in service from one to forty years. Pipe line parallels trolley tracks and passes by power-house on same side of street. One service close to car track was found corroded.

Reply No. 52. About 426 miles of cement-jointed mains are in use with pipes in metallic contact. 250 miles are made with all cement joints. The general use of cement started in 1900. Several lines of trolley roads parallel and cross pipe lines with power houses at different points. No tests have been made and only one case of trouble from electrolysis of a dead pipe near power house has been reported.

Reply No. 54. About 140 miles of cast-iron mains are laid with cement joints. Some mains pass within five feet of power-house. Tests show very slight current on mains. There has been no trouble from electrolysis.

Reply No. 137. Cement joints are used entirely and trouble from electrolysis was experienced on service pipes, particularly where these crossed a line of track where there was heavy traffic. It does not seem that the service pipes carry current to the mains, but that they rather serve as a sort of cross conductor under the several tracks and gather current from the imperfectly bonded rails, which convey to water pipes and damp ground in the vicinity of the sewers and elsewhere. In these cases, particularly in the crowded squares, the services have been covered from the mains to the sidewalk with drain pipes, placing small blocks of wood in the pipes, so that the service pipes are practically in air space. This appears to have remedied the trouble.

Reply No. 138. The mains are laid with all cement joints, and the damage from electrolysis to the cast-iron mains has not been anywhere near as great as the damage to the wrought-iron and steel service pipes. Outside of the cement joints no provision is made to prevent electrolysis on cast-iron mains. Occasionally there is a pipe which is very badly eaten out but as a rule these places are few and far between and the location is usually known.

Extracts Quoting Experience With Insulating Joints.

Reply No. 1. Five lines of 7-inch and 6-inch wrought-iron pipes, each approximately one mile long are in use. The pipes reach a dock at one end and cross under trolley tracks near the other end. Three sets consisting each of five special insulated flanged joints (home-made) have been inserted in each one of the lines, one set at the dock end, one at the trolley end, and one midway between. Before the insulating joints were installed, these pipes were found to carry from 200 to 300 amperes, the current coming in from the water

front, and being delivered to the trolley tracks to which the pipes were ten volts positive. Corrosion was found on pipes where they crossed under trolley tracks but the principal trouble was dangerous sparks at both ends of the lines. The installation of the insulated joints is stated to have obviated this trouble.

Reply No. 2. Nine miles of 2-inch wrought iron mains with Dresser insulating sleeves, 300 feet apart, pass under and parallel trolley tracks and have been two years in service. An electrolytic survey has been made and no trace of electrolysis has been found. There is small leakage from street car lines but not sufficient to cause damage at present.

Reply No. 5. About four and one-half years ago a 4-inch high-pressure wrought-iron gas main was laid which ran immediately under a single trolley track line which was on the near side of the road. The gas main went to the other side and by proper bends paralleled the trolley track for about three miles. The soil was dry clay. Two Dresser insulating joints were inserted in the pipe line about six feet on either side of the trolley tracks. About four months ago this pipe was uncovered at several points along the line on both sides of the trolley track and directly under one of the insulating joints. An examination of the pipe did not reveal any electrolytic action.

Reply No. 6. Dresser insulating couplings are used for steel mains with considerable success. Early last fall tests were made to ascertain current carried and found as high as ten volts and ten amperes positive to rail of trolley road. By means of four couplings placed in successive joints on each side of trolley line, this was reduced to 1.4 volts and 1 ampere. There were two points of almost similar character and both yielded to like treatment. The pipe is now fairly free from current flow although we are still getting considerable from the water pipes which are heavily loaded from poor bonding of rails. We have been able to break it up to a great extent by means of joints before mentioned. It has been our expe-

rience that less than three joints in succession is insufficient as current appears to go around one coupling and to continue on mains. One of our lines (3-inch) runs beside car barn and transforming station and under yard rails. This main is heavily coated with pitch and tarred burlap and connected with insulating couplings for 200 feet each side of yard. We cross under lines at two other points and insulate as mentioned above. The main has been in ground two and one-half years and has never given trouble of any kind due to electrolysis. The water mains are laid with cement joints about 600 feet apart and are bonded to the rails. These have been badly corroded by electrolysis and several hundred feet had to be replaced.

Reply No. 9. A 6-inch wrought-iron pipe line with all Dresser joints is laid within six feet of trolley tracks and transformer station and has been in service six years. Tests show that the main does not carry any measurable current and no trouble from electrolysis has been found.

Reply No. 13. A 2-inch extra heavy wrought-iron main with screw joints connecting Gas Works with filling pots of metal was boxed in coal tar pitch. About thirty amperes was found flowing from works on pipe to filling pots. A number of leaks developed on line, but trouble appears to have been eliminated by dividing the line into insulated sections by insulated joints in addition to the insulating covering.

Reply No. 14. A 16-inch wrought-iron main, 3,000 feet long, was laid with Dresser insulating joints about 19½ feet apart. The pipe line has been in service six years and there are trolley tracks at each end and at right angles to the line. The trolley power-house is about one-half mile beyond and to one side of the pipe line. Tests made show no flow of current and so far no electrolytic action has been found.

Reply No. 17. The amount of pipe used in our system here is in excess of 1,000 miles, and reports to date on tests for electrolysis cover a little over 500 miles. No indications of any of the lines being charged with electricity have been found.

In the construction of the plant we used Dresser insulating couplings for most of the pipe joints. We began the construction of this plant in 1902, and have made tests for electrolysis at intervals of about one year from that time up to the present. Owing to the street railway troubles here the construction of the railway tracks is very imperfect, and our freedom from electric current cannot be attributed to anything but the system of construction adopted by ourselves.

Reply No. 25. Several miles of wrought-iron pipes laid with all Dresser couplings have been in service over five years. The line parallels and runs close to trolley tracks for a considerable distance. Careful tests made show that the line does not carry any measurable current and no experience from electrolysis has been met with.

Reply No. 37. Dresser insulating joints are used on high-pressure steel mains in a number of towns in proximity to trolley crossings, and have been in service from one to six years. Mains close to poorly-bonded tracks have given trouble. Frequent tests are made and where stray current is discovered the R. R. Co. is requested to stop it by bonding rails, etc., and it is to its interest to provide a good carrier for its current.

Reply No. 50. Several miles of wrought-iron mains with Dresser couplings spaced five hundred feet apart were in service eight years. A great deal of trouble from corrosion due to electrolysis was found. These joints are now all bonded over by copper wire and the mains are bonded to the negative return of the power-house.

Reply No. 136. High-pressure wrought-iron main was laid with insulated joints about 500 feet apart. Destructive electrolysis developed close to the joints, and for four to five hundred feet of the main opposite the power house, where most of the pipe was dangerously pitted. This section of main was renewed, and is now connected with five copper cables to the return conductor in the power station. No tests have been made since this was done.

Reply No. 47. Nine miles of wrought-iron mains are laid with an insulating coupling every 500 feet. Trolley tracks parallel most of the line and power-house is about at the middle of the line. Line has been in service for four years. At a point where several car lines come together the pipe was found to be from six to eight volts positive to the tracks and 200 amperes could be drained to the track. So far no signs of electrolysis have been found.

Reply No. 44. Thirty-four miles of 12-inch wrought-iron screw jointed mains are laid with Dresser expansion sleeves located every half mile. The line is seven years old and parallels a very badly constructed trolley road for its entire length. The main is under tracks at places but generally parallels the rails at an average distance of about fifteen feet. Three power-houses are located along the line of this main. Pitting with consequent leaks was found where the main laid in damp soil in vicinity of power-houses. Trouble is due to electrolysis, as the small recesses in the pipe were filled with a dark substance and the surrounding soil was colored by the impregnated iron. Voltmeter tests showed the gas mains positive to the rails at these points.

Extracts Quoting Experience with Insulating Pipe Coverings.

Reply No. 4. Since 1898 service pipes have been coated with a paint made of a mixture of coal tar, crude rubber dissolved in turpentine and resin. In localities where 2-inch pipe had to be renewed once in nine months it was found that this paint increased the life to about two and one-half years.

Reply No. 7. In the positive area where mains cross under trolley tracks they are enclosed in a wooden box and the space between the pipes and the box is filled with cement. The object in using cement is not so much to protect the pipes from electrolytic damage as to protect them from mechanical injury after a certain amount of corrosion has taken place. This

is not considered by any means an approved protection, but it has given some protection.

Reply No. 12. The coating known as "Cincinnati Mixture" is used for service pipes only. This mixture consists of coal tar and other ingredients. In addition to this coal tar coating, the pipes are wrapped with muslin, which is afterward painted with tar. Our experience is that this form of covering of the service pipes prevents ordinary corrosion, but does not fully prevent electrolytic action.

Reply No. 13. A 2-inch extra heavy wrought-iron main with screw joints has been boxed and covered with No. 6 coal tar pitch. This main connects the gas works with filling pots of metal. The main was found to be carrying about 30 amperes from the works to the filling pots. A few cases of leaks were found in this main. In some of these it was found that dirt had been permitted to get into the pitch and then probably formed the first opening to the pipe. Other leaks were found where the pitch had been disintegrated or decomposed, leaving a brown powdery material. The trouble has been eliminated by dividing the line into insulated sections. Service pipes have been surrounded by a "V" shaped trough and then covered with a mortar composed of coal tar and sand well tamped and heap over the middle. This mixture has given ample protection from corrosive action of the soil, but has not helped materially from electrolysis.

Reply No. 14. Experience with insulating coverings on services has shown that they retard a general corrosion, but any spot that becomes exposed is destroyed more readily than if the area exposed were larger.

Reply No. 22. In 1886 our services were first laid in a "V" shaped trough. This trough was made of 1" x 4" undressed white pine strips. We gave the pipe a coating of coal tar and then filled the box with a mixture of tar and sand after which the box was closed by placing another strip on top. It was found that this was a good preventative to the pipes from rust, corrosion and frost, and where other trenches had undermined

our service pipes this box served as a support to prevent the pipe from settling and trapping. However, it did not protect the pipe from electrolysis, as our experience has proven. About three years ago the practice of boxing services was discontinued.

Reply No. 26. Service pipes crossing under tracks were laid in wooden boxes filled with tar, but it was found that while the boxed portions of services were protected, the pipes were eaten out on each side of the box; and services laid without boxes close to those boxed showed no signs of electrolysis.

Reply No. 29. There has been a great deal of trouble from services being eaten out by electrolysis. To protect the services some have been placed in a trough of cement particularly in the neighborhood of the power-houses and where the ground is very wet. In several cases this cement cracked and the services have been eaten out at such points; in other cases services have been eaten out beyond the points where they were cemented, that is which were beyond the curb line.

Reply No. 32. Several coatings on services have been tried but only one has proven effective; this is a substantial covering of coal tar pitch poured hot into a box around the pipe. During four years' service not a single case of corrosion has been found.

Reply No. 33. Service pipes have been protected by boxing and filling box with coal tar pitch, the covering extending about six feet beyond the rails on each side. This appears satisfactory, since services which were formerly eaten out as often as three times in one year are now twenty months in service and have developed no trouble.

Reply No. 39. At present Cremo coating is used, which is composed of coal tar, powdered lime, powdered resin, tallow and rubber cement. This compound is applied to service pipes while hot and wrapped spirally with light drilling. This coating affords a fairly good protection to service pipes.

Reply No. 43. Service pipes which have been used to replace those affected by electrolysis have been coated with Elateroid 0.5 paint during the past three years and this has given satisfaction. One pipe used to be replaced every four months.

Reply No. 44. A pipe was enveloped with concrete, but this did not prevent electrolysis, but apparently retarded the action. Insulating (mica compound) couplings between main and services have also been used, but found that they did not prevent electrolysis.

Reply No. 46. A 1¼-inch service pipe from a cast-iron main near power-house was found entirely destroyed two years ago. This was replaced by a new service pipe which was encased in a tar and cement concrete, cutting the acid in the tar with lime. Upon close examination one year later the current had not affected the service pipe nor the gas main.

Reply No. 53. About two years ago the service pipes in one locality were covered with a cement coating and no trouble has developed since.

Reply No. 138. Some of the 3-inch mains were laid in concrete the latter being very carefully made and the whole work being very carefully done. In spite of this a few cases of slight electrolysis developed and it was clear that the concrete used alone did not prevent electrolysis. A portion of one of these 3-inch mains was laid by constructing a box and surrounding the pipe with from two to three inches of hot pitch, but here again electrolysis developed. It seems that the work was not well done at the points where the boards composing the box were put together. Recently this main was uncovered and the pitch removed, and it was found that where the pipe was covered with pitch it was bright and clean. It seems certain, therefore, that if the pipe is surrounded with two inches of pitch and the whole encased in a box so as to prevent mechanical damage, the pipe will be very fully protected. In the positive districts of the city or where there is a certain black soil which corrodes pipes very rapidly the service pipes are treated in the following manner:

First, the service pipes are heated by running steam through them and then a coating of tar in which the ammonia has been killed with lime is brushed on the pipes, a layer of Manila paper is then wound on, then a second coating of pitch, then a third coating of paper, and frequently a fourth layer composed of pitch and paper as above. The last coating of paper is simply used to facilitate handling. This method of protecting the service pipes has proven very efficient and very few pipes so treated have failed. A few pipes, however, which were so coated have been destroyed by electrolytic damage. It may be, however, that this was caused by some mechanical injury to the coating.

THE PRESIDENT: Gentlemen, what action shall be taken on the Report of the Committee on Electrolysis?

MR. GARTLEY: I move that it be accepted.

The motion was seconded.

MR. MCDONALD, OF LOUISVILLE: Prof. Ganz in his brief abstract has told us a great many things about electrolysis. He does not tell what progress has been made towards compelling the railroads to take care of their own stray currents, and that is what I should like to have heard. I am told there are some cities in which that has been done; whether legally or otherwise I don't know, but, if any progress has been made in that direction which would be of assistance to other companies in compelling their railway companies to take care of their currents, it would be very welcome information to me, and I presume it would be to some other gentlemen.

PROF. GANZ: In that connection I can only say that I do know of two cases where railroad companies are taking care of their own currents, but I am not prepared to speak of them. I do know of a good many others where they are paying for damage, that I am also not prepared to speak of. Perhaps some of the gas men present here can talk of this,—I see some who are receiving from railroad companies money

to pay for damage from electrolysis—it is up to them to speak out.

THE PRESIDENT: Do the gentlemen desire to discuss this question further?

(The question was called for)

THE PRESIDENT: The motion then is, on the acceptance of the Report of the Committee on Electrolysis. All those in favor of that motion will manifest it by saying aye. The motion was carried.

The next matter on the program is the

REPORT ON UNIT OF LIGHT.

DR. A. C. HUMPHREYS, *Chairman.* The report will be read by Mr. Gartley.

MR. GARTLEY: I will not take the time to read the report in full. I simply want to say that the appointment of this Committee, and the procedure that led up to it, is all set forth in last year's proceedings. The Committee was finally appointed to express the views of the American Gas Institute on their agreement to accept the value of the unit of light that was about to be agreed upon by the various Governmental laboratories in France, England and this country. We wanted to know still more surely than we did up to that time how the new unit would compare with the old. We felt that the American Gas Institute was far more interested in this matter than any of the other societies. The result has been that all the countries have adjusted themselves to a value of the unit that does not materially differ from that which is now used by the gas companies, which was a great load off the minds of the committee. We therefore notified the Bureau of Standards that we acquiesced in the proposed value..

Another purpose for which this committee was appointed was to confer with the Bureau of Standards on other matters referring to the gas business. A question that came up was one of finer graduations and finer specifications for the Pentane lamp. They found that some of the American lamps

varied far too much from what they should in their value. The Bureau of Standards, in their last year's requisition on the government for money, included a sum of $10,000 for work to be done in investigating the eccentricities of the Pentane lamp, and finding out what caused the apparent fluctuations that up to this time have been unexplained. Considerable progress has been made in that direction. The Bureau of Standards is still at work, and I would, as this report suggests, recommend that the new Technical Committee work in conjunction with the Bureau of Standards and follow this matter up very closely. But, so far as the unit of light is concerned, I am very glad to say the thing is accomplished, and we have what we wanted. There is just one paragraph I want to read to you: "That your committee avails itself of this opportunity to put on record its keen appreciation of the broad view of the situation adopted by the Bureau of Standards in consulting with the associations representing the lighting interests of this country before committing itself to a definite course of action. Had the Bureau of Standards at Washington been represented by men deficient in ability to appreciate the working conditions existing in practice, this happy result, only obtainable through the co-operation of the commercial interests concerned, would never have been reached."

Report of Special Committee of American Gas Institute Appointed to Confer With Bureau of Standards on Unit of Light.

Your Committee on the Unit of Light was appointed in October, 1908, with power to give the final assent, or dissent, of this Institute to the Statement and Resolutions adopted by the Joint Committee, composed of sub-committees of the American Institute of Electrical Engineers, the American Gas Institute and the Illuminating Engineering Society, at a session held in New York, February 14, 1908. (See page 405, Institute Proceedings, 1908).

The Committee was also empowered to represent the Institute in conferring with the Director of the Bureau of Standards, when invited so to do by him, on all matters referring to the Gas Industry.

The point at issue at the time of the last convention is set forth in the resolution to be found on pages 422 and 423, Institute Proceedings, 1908.

Briefly stated, there was uncertainty as to whether the proposed new unit would so differ from the one generally in use by our industry as to cause a serious disturbance in our business. It was proposed to test this by sending to the Bureau of Standards a Pentane lamp, bearing the certificate of the Secretary of the English Gas Referees, to have its value expressed in terms of the proposed new unit. The lamp selected was received in this country in 1899 and has been used extensively in giving values to lamps of American manufacture sold to gas companies in America.

On December 23, 1908, the Bureau reported:—

"We find the Chance lamp (W. J. A. B. No. 51) in close agreement with out standard Pentane lamps, and correct within 2 per cent., in terms of the standard candle of the Bureau on the new basis; that is, after decreasing our unit 1.65 per cent. as we shall shortly do, to come to a common value with England and France."

The information contained in this report confirmed your Committee in the belief that the proposed change in the Bureau Unit would in no way disturb the gas industry, and this made it possible for the Committee to agree upon approval of the Joint Resolutions.

The following correspondence will show the progress made:

"Department of Commerce and Labor, Bureau of Standards, February 11, 1909, to Mr. C. O. Bond, Secretary, Joint Committee on Unit of Light, Philadelphia.

Dear Sir.—We have reached an agreement with the National Physical Laboratory of England and the Laboratoire Centrale of France, whereby we are to fix the International Can-

dle at 1.6 per cent. below the value of the candle which has been maintained at the Bureau since its organization, and expect that a simultaneous announcement of this arrangement will shortly be made in America, France and Great Britain.

We have recently tested a number of Pentane lamps and certified them in terms of this new unit, and find that when reduced to a standard condition of eight liters of water vapor per cubic meter at normal barometric pressure, and burned in a very well ventilated room, the value of the English Pentane lamps and some of the American, is 10 candle-power within a tolerance of plus or minus 2 per cent. This, of course, is as we expected it would be, and shows that the gas interests that have been using the unit as given by the English Pentane lamps will not have to make any change in the rating of their working standards.

Has the Committee of the American Gas Institute taken any action on this matter as yet? We would like to be able to say in making the announcement that the Institute has officially recognized the new unit of light.

Respectfully,

(Signed) S. W. STRATTON, *Director.*"

New York, February 26, 1909.

Mr. W. H. Gartley, Chairman of the Committee representing the American Gas Institute in the Joint Committee composed of the American Society of Electrical Engineers, the Illuminating Engineering Society and the American Gas Institute on fixing upon the value of the Unit of Light, Philadelphia, Pa.

"Dear Sir.—I have been informed through a letter from Dr. S. W. Stratton, addressed to Mr. C. O. Bond, Secretary of the Joint Committee on the Unit of Light, that the Bureau of Standards has 'reached an agreement with the National Physical Laboratory of England and with the Laboratoire Centrale of France, whereby we are to fix the International Can-

dle at 1.6 per cent. below the value of the candle which has been maintained at the Bureau since its organization.'

As Chairman of the Committee of the American Gas Institute, appointed to confer with the Director of the Bureau of Standards on the subject of the Unit of Light and other matters and that Committee having been appointed, by vote of the Institute, to decide whether the Institute would, or would not approve the adoption of the Resolutions proposed by the Joint Committee, I now wish to notify you that the Committee has decided to approve those Resolutions, copy of which is attached.

Yours very truly,

(Signed) ALEX. C. HUMPHREYS,

Chairman of Special Committee on International Unit of Light.

There was attached a copy of the Joint Resolutions.

Mr. S. W. Stratton, Director, Bureau of Standards, Washington, D. C.

Dear Sir.—Immediately upon receipt of your letter of above date (February 11, 1909,) I communicated with the members of the American Gas Institute Committee, asking the result of their deliberations to date. I am able to transmit today the enclosed letter to Mr. W. H. Gartley, from the Chairman of that Committee, he having in turn sent it to me, as representing their final action.

As this completes the approval of the original resolutions by the three Societies appointing sub-committees to the Joint Committee, I now state to you, as Chairman of the Joint Committee, the final result.

Awaiting your instructions as to whether there will be any necessity for further action by said Joint Committee, I remain,

Very respectfully yours,

(Signed) CHAS. O. BOND,

Secretary, Joint Committee, Unit of Light."

This completed the first step—the procurement of an agreement by the American technical societies to the contemplated change by the Bureau of Standards in the value of the Bureau Unit. That change consisted of the reduction of the former value to the one which did not differ, within errors of observation, from the one then in use by our gas companies.

Meanwhile, pending this final decision by this Institute, the Bureau of Standards entered into correspondence with the foreign national laboratories in regard to the possibilities and terms of agreement on a value which might be accepted as an international unit. The following history is extracted from Dr. E. P. Hyde's Report to the Illuminating Engineering Society, September, 1909:—

Following various informal conferences among the directors and other representatives of the different national laboratories, and after further determinations of the relations of the various national units, an agreement was reached by the Directors of the Bureau of Standards, Washington; Laboratoire Centrale d'Electricite, Paris, and National Physical Laboratory, London, upon a common unit of light, which should be maintained constant through the co-operation of the three laboratories.

The announcement of adoption of the unit was made in this country by the Bureau of Standards in Bureau Circular No. 15, May 20, 1909. (See copy appended hereto).

The proposal to call this common unit of light the "International Candle" has been submitted to the International Electro-chemical Committee, which will endeavor to secure the endorsement of the proposal by all the countries of the world which are represented on that Commission

Your Committee has also to report that in view of the difference in value of some of the American and English Pentane lamps that the question of investigating the effect upon the lamps of different proportions of diluent incombustible gases and atmospheric vapors contained in the air supplied to the lamps be made a subject of special study by the Bureau of Standards at Washington, as well as the effect of varying

materials and dimensions in the basic features of the lamps.

In this connection, the Bureau of Standards included in their requisitions for 1910 a sum of $10,000.00, which was granted by Congress, for the purpose of such investigation.

There has also been received in this country a standard Pentane ten-candle lamp from England, bearing official certificates of correct value from the London Gas Referees and the British National Physical Laboratory. This lamp is probably the only one in this country having the endorsement of both of these bodies.

We recommend that the Technical Committee to be appointed keep themselves closely informed regarding the development of the experiments being conducted on the Pentane lamp by the Bureau of Standards, offering their services in consultation and at the proper time inform this Institute of the progress made. We are now in possession of a fixed international unit. We look forward to securing a practical reproducible standard.

Your Committee avails itself of this opportunity to put on record its keen appreciation of the broad view of the situation adopted by the Bureau of Standards in consulting with the associations representing the lighting interests of this country before committing itself to a definite course of action. Had the Bureau of Standards at Washington been represented by men deficient in the ability to appreciate the working conditions existing in practice, the happy result, only obtainable through the co-operation of the commercial interests concerned, would never have been reached.

Your Committee having performed all the duties imposed upon it by this Institute and having brought those duties to a successful conclusion, asks to be discharged.

ALEX. C. HUMPHREYS, Chairman,
WALTON CLARK,
W. H. GARTLEY,
A. G. GLASGOW,
R. B. BROWN,
Committee on Unit of Light,

A Proposed International Unit of Light.

(Issued from the Department of Commerce and Labor, Bureau of Standards, Washington, D. C., under date of May 20, 1909, under the classification "Bureau Circular, No. 15; 2d Edition," superseding the first Edition, issued April 1, 1909.)

The following announcement relative to the unit of light of America, France and Great Britain, is being made simultaneously in these three countries. The announcement is being made in Great Britain by Dr. R. T. Glazebrook, Director of the National Physical Laboratory, and in France by Prof. Paul Janet, Director of the Laboratoire Central d'Electricité.

In order to determine as accurately as possible the relations between the photometric units of America, France, Germany and Great Britain, comparisons have been made at different times during the past few years between the unit of light maintained at the Bureau of Standards, Washington; at the Laboratoire Central d'Electricité, Paris; at the Physikalische-Techniche Reichsanstalt, Berlin, and at the National Physical Laboratory, London.

The unit of light at the Bureau of Standards has been maintained through the medium of a series of incandescent electric lamps, the values of which were originally intended to be in agreement with the British unit, being made 100/88 times the Hefner unit.

The unit of light at the Laboratoire Central is the bougie décimale, which is the twentieth part of the standard defined by the International Conference on Units of 1884, and which is taken, in accordance with the experiments of Violle, as 0.104 of the Carcel lamp.

The unit of light at the Physikalische Techniche Reichsanstalt is that given by the Hefner lamp burning at normal barometric pressure (76 cm.) in an atmosphere containing 8.8 liters of water vapor per cubic meter.

The unit of light at the National Physical Laboratory is that given by the 10-candle-power, Harcourt pentane lamp,

burning at normal barometric pressure (76 cm.) in an atmosphere containing 8 liters of water vapor per cubic meter.

In addition to the comparisons of electric and flame standards, carried out recently by the national laboratories in Europe, one comparison was made in 1906, and two in 1908 between the American and European units by means of carefully seasoned carbon filament electric standards, and as a result of all the comparisons the following relationships are established between the above units.

The pentane unit has the same value within the errors of experiment as the bougie décimale. It is 1.6 per cent. less than the standard candle of the United States of America, and 11 per cent. greater than the Hefner unit.

In order to come into agreement with Great Britain and France, the Bureau of Standards of America proposed to reduce its standard candle by 1.6 per cent. provided that France and Great Britain would unite with America in maintaining the common value constant, and with the approval of other countries would call it the International candle. The National Physical Laboratory, London, and the Laboratoire Central d'Électricité, Paris, have agreed to adopt this proposal in respect to the photometric standardization which they undertake, and the date agreed upon for the adoption of the common unit and the change of unit in America was April 1, 1909.

The following simple relations will, therefore, hold after that date:

1 International Candle = 1 Pentane Candle.
1 International Candle = 1 Bougie Décimale.
1 International Candle = 1 American Candle.
1 International Candle = 1.11 Hefner Units.
1 International Candle = 0.104 Carcel Unit.
Therefore 1 Hefner Unit = 0.90 International Candle.

The pentane and other photometric standards in use in America will hereafter be standardized by the Bureau of Standards in terms of the new unit. This, within the limits

of experimental error, will bring the photometric units for both gas and electrical industries in America and Great Britain, and for the electrical industry in France to a single value, and the Hefner unit will be in the simple ratio of 9/10 to the International candle.

The proposal to call the common unit of light to be maintained jointly by the national standardizing laboratories of America, France and Great Britain, the "International candle," has been submitted to the International Electro-technical Commission, which will endeavor to secure the indorsement of the proposal by all countries of the world which are represented on that Commission.

It is hoped that such general approval may be secured, and that in the near future the term "International Candle" will receive general sanction.

The above announcement marks an important step forward in the history of photometric measurements. For many years the British parliamentary candle was the unit recognized in this country, but the lack of precision in practical photometry did not permit its value to be very accurately expressed or reproduced. In recent years the gas industry has employed the 1-candle-power sperm candle, the 10-candle-power Harcourt pentane lamp, the Hefner lamp, and various secondary standards, while the electrical industry has employed incandescent electric lamps either certified by the Bureau of Standards or rated in terms of standards that are consistent with those of the Bureau. The unit of the Bureau has been maintained very constant, as shown by frequent comparisons with the standards of France, Germany and Great Britain, but differed appreciably from the British unit and hence from the unit employed by most of the gas companies in America.

The Bureau of Standards took the initiative several years ago in bringing about international uniformity in the unit of light by sending its representatives abroad with copies of its standards to determine more accurately the relative values of the units of the several European countries and to urge the

adoption of an international unit. In this country the American Institute of Electrical Engineers, the American Gas Institute, and the Illuminating Engineering Society have acted together in support of the movement, and have voted in advance to recognize the new unit of candle-power.

In England the National Physical Laboratory has secured the indorsement of the London Gas Referees and the Institution of Gas Engineers.

The union of the three national standardizing institutions of America, France and Great Britain in maintaning a common unit of candle-power, and the co-operation of the German Reichsanstalt in redetermining, from time to time, the ratio of the Hefner unit to the common international candle, assures the highest attainable constancy for the new unit of light.

Unfortunately there is no primary photometric standard that is sufficiently constant and reproducible to be generally accepted as an international standard. France, Germany and Great Britain each has its own primary flame standard, and a great deal of effort has been expended in attempting to determine accurately the relations between them. Until the flame standards themselves are better understood, however, and the atmospheric and other conditions more perfectly controlled, the unit of light cannot be preserved as accurately by primary flame standards as by incandescent electric secondary standards. The latter, when well made, properly seasoned, and carefully measured, permit comparisons to be made (using the means of many settings on several lamps) with excellent precision, the lamps themselves being constant enough and the precision of measurement high enough to fix the final values to about one or two-tenths of 1 per cent. There is good reason to believe that in this way the international unit of light can be preserved so nearly constant that any inevitable drift occurring one way or the other would be too small to detect with certainty by any of our present flame standards in many years. The Bureau of Standards will continue to standardize flame standards by the electric standards and will also carefully in-

vestigate the more important flame standards. Similar tests and investigations will also be made in Europe, and if any appreciable drift does occur it will sooner or later be detected.

Careful distinction should be made in this connection between a *unit* and a *standard*. An international unit maintained by the co-operative effort of several national standardizing institutions, and checked from time to time by means of all the best primary standards in use, is more likely to be maintained constant than if it were defined to be represented by any single primary standard, unless such a primary standard were reproducible to a very high degree of precision. Such a *unit* can be continued permanent even though all present primary *standards* are ultimately superseded by better ones. The Hefner lamp as a convenient flame *standard* will not be displaced in America or any other country which adopts the international candle as its unit of light. Uniformity among different countries and continuity of value are prime necessities with respect to the *unit*. But the particular standard by which the unit is realized in practice is largely a matter of convenience and circumstance. In the photometry of electric lamps, electric standards are most suitable. In gas photometry one form of flame standard or another will be employed according to circumstances. It is not expected that all countries of the world will at once adopt the proposed international candle as their unit of light. Those countries which already have the Hefner unit in general use may prefer to continue it. But if all countries which have a unit differing appreciably from the Hefner shall adopt the international candle as their unit, there will then be only two units in use throughout the world, and they will have the simple ratio 9:10. This would result in a distinct gain both in the practice of photometry and in definitions and nomenclature.

The effect of this change of 1.6 per cent. in the unit of the Bureau, which is in general use for electric lighting throughout the country, is to raise the candle-power rating and de-

crease slightly the watts per candle of electric lamps. A 16-candle-power lamp will give 16.26 candles in the new unit, or a 16-candle-power carbon filament lamp burning at 110 volts will give 16 candles on the new basis at 109.69 volts. The change, though small, is important in the photometry and rating of lamps.

The new unit of candle-power being in agreement with the present English unit as represented by a 10-candle-power standard pentane lamp, there will be no change in the unit of light now employed by those gas companies which use pentane lamps, provided they are in agreement with the English standard. But as pentane lamps may differ slightly from one another, even when burned under the same conditions, it is desirable for the sake of greater uniformity to have them standardized in terms of the standard candle of the Bureau. These variations, amounting to from 1 to 5 per cent., are generally in the same direction; that is, the lamps if not correct usually give less than 10 international candles under standard conditions when burning in a pure atmosphere at a normal barometric pressure of 76 cm. of mercury and an atmospheric humidity of 8 liters of water vapor per cubic meter. In anticipation of this change some of the largest gas companies in the United States have already had their pentane and Hefner standard lamps standardized by the Bureau in terms of the new unit.

Gas standards will hereafter be certified in terms of the international candle, electric standards will be certified in terms of the old unit until July 1, 1909, unless otherwise requested On July 1 the new unit will be adopted by the Bureau of Standards in the certification of electric standards, and it is hoped that manufacturers of electric lamps will adopt the new unit as soon thereafter as possible.

The Bureau recommends that all gas and electric companies, all photometric laboratories, and all the manufacturers of electric lamps in the United States adopt the new unit of candle-power, if possible, not later than January 1, 1910.

Further information with regard to change of photometric

unit or to the testing of gas and electric standards will be given on request.

THE PRESIDENT: You have heard the report of the Committee on Unit of Light. What action shall be taken?

MR. ADDICKS: I move that it be approved.

The motion was seconded and carried.

THE PRESIDENT: The next thing is the

REPORT OF THE COMMITTEE ON BENZOL ENRICHMENT, of which Mr. Shattuck is Chairman.

Mr. Shattuck then read his report as follows:

REPORT OF COMMMITTEE ON BENZOL ENRICHMENT.

On investigating the use of benzol as an enricher of illuminating gas, your Committee finds that as the result of its being manufactured mainly in by-product oven plants, by far its most important use in this country as an enriching material has been to raise the candle-power of the coal gas obtained in the manufacture of coke in by-product ovens.

The companies manufacturing by-product oven gas have made a careful study of the practical conditions governing the enrichment of their product by the use of commercial benzol, and the communications received from Mr. Warren S. Blauvelt, at Detroit, and from Mr. L. M. Whitwell, at Milwaukee, both of the Semet-Solvay Co., give some of the results of such study. These communications are attached to this report as an appendix.

Perhaps the most important work done by the Semet-Solvay Co. has been the confirmation in practical work of Dr. Bunte's figures showing the varying enrichment value realized from benzol in candle-feet per gallon depending upon the quantity of benzol carried by the gas. Mr. Whitwell describes in a most instructive way the experiments made to determine this point, and adds practical examples and charts illustrating the varying possibilities of enrichment with benzol.

It is important to call particular attention to the fact that enrichment by benzol adds but little to the heating value of the

gas enriched. The addition of .1 gallon of benzol to 1000 cu. ft. of gas increases its heating value by only about 12 B. T. U. even when no low-tension vapors are thrown down, and since the heating value of gas is today at least as important as its candle-power, the first essential for the successful use of benzol enrichment is that the gas must already have a satisfactory thermal value. For this reason benzol can never entirely replace gas oil for the enrichment of water gas: the approximately one gallon of benzol required to raise 1000 cu. ft. of blue water gas to 21 or 22 candle-power would only raise the heating value to about 425 B. T. U. per cu. ft.

On the other hand, coal gas, whether made in coke ovens or in retorts, is comparatively low in candle-power but possesses the necessary initial heating value to make it suitable for enrichment by benzol.

Benzol may have an important use as an enricher for water gas in cases where sufficient oil has been used in the manufacture of the water gas to give it the necessary heating value, but where the candle-power has been reduced by the loss of hydrocarbon vapors due to cooling or compression.

Practical results confirm theory in condemning the use of benzol to enrich at the works any gas already saturated with hydrocarbon vapors; the low tension vapors will be deposited in transmission to a greater or less extent depending upon the temperature and pressure conditions and the final candle-power reaching the consumer is likely to show that a very disappointing enriching value has been realized for the benzol used.

The Committee has received a report from one works manufacturing ⅓ water gas and ⅔ coal gas, covering a full year's use of benzol to replace a portion of the gas oil formerly used. The enriching was done at the works and the report shows an average enriching value of about 28,000 candle-feet per gallon of benzol.

However, as the quantity of street drip was increased by the use of benzol, it is probable that the enrichment value measured by the candle-power at point of consumption was

much less than that shown by the works candle-power readings.

To insure a permanent and commercially successful increase in candle-power by the use of benzol, it is usually necessary to prepare the gas by removing a portion of the low tension hydrocarbon vapors. This may be done by compression, by cooling or by washing the gas with an absorbent oil.

Mr. Blauvelt's paper given in the Appendix to this report, describes the latter method as carried out at Detroit, and Mr. Whitwell gives the results obtained at Milwaukee in the enrichment of coke-oven gas after compression to 1½ to 2 lbs.

The conditions controlling the commercial success of benzol enrichment are the comparative costs of benzol and gas oil, and the quality of benzol available; the initial candle-power and heating value of the gas to be enriched and its condition with respect to saturation with hydrocarbon vapors and the character of such vapors; the conditions of temperature and pressure to which the gas will be exposed after enrichment.

These factors having been determined, there are enough data available, both practical and theoretical, to make it possible to give a close estimate of the probable results to be obtained by enrichment with benzol.

The Committee desires to emphasize its conviction that there are many cases where enrichment by benzol has practical and economic advantages over any other method of enrichment, but that each case constitutes a separate problem requiring careful study.

E. H. Earnshaw,
W. S. Blauvelt,
V. F. Dewey,
L. M. Whitwell,
W. H. Snow,
A. C. Wilke,
J. D. Shattuck, Chairman,
Committee.

SUBMITTED TO MR. J. D. SHATTUCK, CHAIRMAN BENZOL ENRICHMENT COMMITTEE, AMERICAN GAS INSTITUTE.

BY L. M. WHITWELL, *Semet-Solvay Company, Milwaukee, Wis.*

BENZOL ENRICHMENT.

In working with benzol enrichment widely varying results have been obtained by different operators and different companies as to enriching values realized. It is, of course, upon the enriching value realized that the success of benzol enrichment depends.

There appear to be two general reasons for the wide variations in results: First, the amounts of benzol retained by gas have been different under different conditions, and, consequently, wide variations in enriching values have been realized. Second, the quantity of benzol present before enrichment, as well as the amount added, materially affects the enriching value which is possible.

Upon the vapor tension of benzol is based the whole theory of benzol enrichment. Quite as important as the vapor tension of the benzol which is used for enrichment is the vapor tension of the oil mixture present in the initial gas before enrichment. In coal gas the oil mixture present in the gas before enrichment is largely benzol. Mr. E. H. Earnshaw explained most clearly the laws of vapor tension as applied to benzol enrichment in his paper read before the American Gas Institute and published in the proceedings of 1908, page No. 247, and, therefore, the theoretical side of the subject will not be discussed here, although later some phases of the application will be taken up. To anyone interested in benzol enrichment a very careful study of Mr. Earnshaw's paper is recommended, inasmuch as the laws explained in this paper must be thoroughly understood if the best results are to be obtained with this process of gas enrichment.

Distinct from the capacity of gas to carry benzol, which is dependent upon the vapor tensions, is the candle-power which can be obtained when oils of this series are retained. It is, of course, impossible to predict what results will be obtained with benzol enrichment if the vapor tension of the oil mix-

ture present in the gas before enrichment, of the enriching benzol used, or of the mixture of the two, is such that any of the oils will not be retained under the temperature and pressure conditions to be met with. Therefore, it is of value to consider what candle-powers can be realized provided benzol is retained by the gas. Later on, various methods will be discussed which are applicable for the production of oil mixtures which will be retained.

To determine the candle-power results realized per unit of benzol reaching the burner under commercial conditions, the following work was done. At the Semet-Solvay Company's operations at Milwaukee, Chicago and Detroit, at various stations ranging from 100 yards to 15 miles from the works, oils (benzol) present in the gas were extracted and carefully measured per unit of gas. Candle-power determinations were made before and after extraction of the benzol and the difference taken as candle-power due to oils (benzol). Gases varying from 8.00 to 20.00 candle-power were worked with. Tests were made on unenriched gas at the works; on gas immediately after enrichment; and on gas after transmission under both low and high pressures. The general character of the gases is shown by the following analyses:

	Chicago	Milwaukee	Detroit
CO_2	2.2	1.8	1.4
C_6H_6	1.1	2.5	1.7
C_2H_4	4.0	2.3	3.4
O_2	.4	.7	.4
CO	3.9	4.5	4.4
H_2	50.2	42.7	48.4
CH_4	35.6	37.6	36.0
N_2	2.6	7.9	4.3
	100.0	100.0	100.0
B. T. U. by Junkers calorimeter	655	650	654

It may be well to mention at this point that as far as the study has been pursued, no definite relation has been established between candle-powers and the per cent. of "illuminants" (either C_6H_6 series or C_2H_4 series), as determined by ordinary gas analysis methods. This is mentioned as a precaution against trying to make candle-power results comparable with gas analyses. It has been published at times that a certain per cent. by volume of benzol is equivalent to certain candle-power. This is unquestionably true, but, owing to the uncertainty of analytical methods this is an unreliable basis on which to work.

The gas was made in Semet-Solvay coke ovens as a by-product in the manufacture of metallurgical coke.

The results of the tests, in candle-power due to various contents of benzol, are shown in the attached chart No. 1 and also table No. 1.

In the *Journal Fur Gasbeleuchtung,* 1893, page No. 442, Dr. Bunte publishes results of some of his work on the illuminating value of benzol with coal gas. This data has been transposed into terms of candle-power per gallon of benzol per M. cu. ft. of gas, and a curve plotted therefrom is shown on chart No. 1, together with the results obtained at Detroit, Chicago and Milwaukee in commercial practice on a large scale. The results with the coke oven gas are found to parallel very closely Dr. Bunte's work. As the curve for Dr. Bunte's work represents very nearly an average of the conditions found in actual practice, and as his work was probably more accurately executed, it is considered that this curve represents the candle-power which can be realized per unit of benzol carried to the burners with gas of this character.

Attention is called to the rapidly decreasing candle-power realized per unit of additional oil.

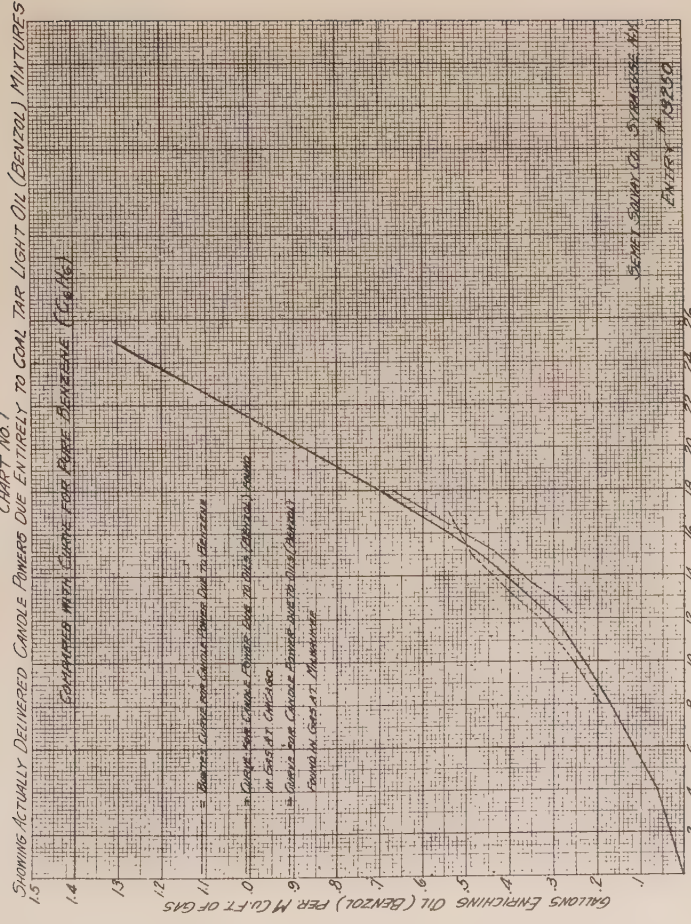


CHART No. 1
SHOWING ACTUALLY DELIVERED CANDLE POWERS DUE ENTIRELY TO COAL TAR LIGHT OIL (BENZOL) MIXTURES
COMPARED WITH CURVE FOR PURE BENZENE (C_6H_6)
= Points Curve and Candle Power due to Benzene
= Curve for Candle Power due to Illuminants in Gas at Chicago
= Curve for Candle Power due to Illuminants found in Gas at Manhattan
GALLONS ENRICHING OIL (BENZOL) PER M CU. FT. OF GAS
CANDLE POWERS
SEMET SOLVAY CO. SYRACUSE, N.Y.
ENTERED 1920

.1	gal.	per	M.	yields	5.5	C.P.	= 5.5	C.	P.	per	unit	of benzol.
.2	"	"	"	"	9.0	"	= 4.5	"	"	"	"	"
.3	"	"	"	"	12.0	"	= 4.0	"	"	"	"	"
.4	"	"	"	"	14.0	"	= 3.5	"	"	"	"	"
.5	"	"	"	"	15.5	"	= 3.1	"	"	"	"	"
.6	"	"	"	"	16.8	"	= 2.8	"	"	"	"	"
.7	"	"	"	"	18.0	"	= 2.6	"	"	"	"	"
.8	"	"	"	"	19.0	"	= 2.4	"	"	"	"	"

From the curve showing the candle-powers for the various contents of benzol, which curve was substantiated in actual practice, the amount of benzol which it is necessary to add to a gas of known candle-power in order to produce a desired enrichment can be obtained, provided that it is known what proportion of the candle-power of the gas to be enriched is due to benzol. If this proportion is not known the amount of benzol required for certain candle-power increase may vary as much as 100%. Therefore, the result of benzol enrichment, even when the vapor tensions are such that the oil is satisfactorily retained, will vary with the oil content of the gas to be enriched as well as with the amount of enrichment desired. In other words, it is dependent upon the total oil content.

To bring out the various possibilities of benzol enrichment chart No. 2 and table No. 2 are presented in which it is aimed to show the amount of enriching benzol required to produce various finished candle-powers due to benzol, from various initial candle-powers due to benzol. Chart No. 2 is entirely an adaptation of chart No. 1 which is based upon actual practice.

In chart No. 2 the vertical lines show initial candle-powers due to oils only. The broken curved lines show finished candle-powers due to oils only. Horizontal lines from the intersections of the vertical lines and the broken curved lines show the amount of oil required for any given condition.

CHART No 2

SHOWING POSSIBLE FINISHED CANDLE POWERS AND ENRICHING VALUES FROM VARIOUS INIL C.P.S DUE TO OILS (BENZOL) AND USING VARIOUS AMTS. OF ENRICHING OILS (BENZOL)

INITIAL CANDLE POWER DUE ENTIRELY TO COAL TAR LIGHT OILS (BENZOL)

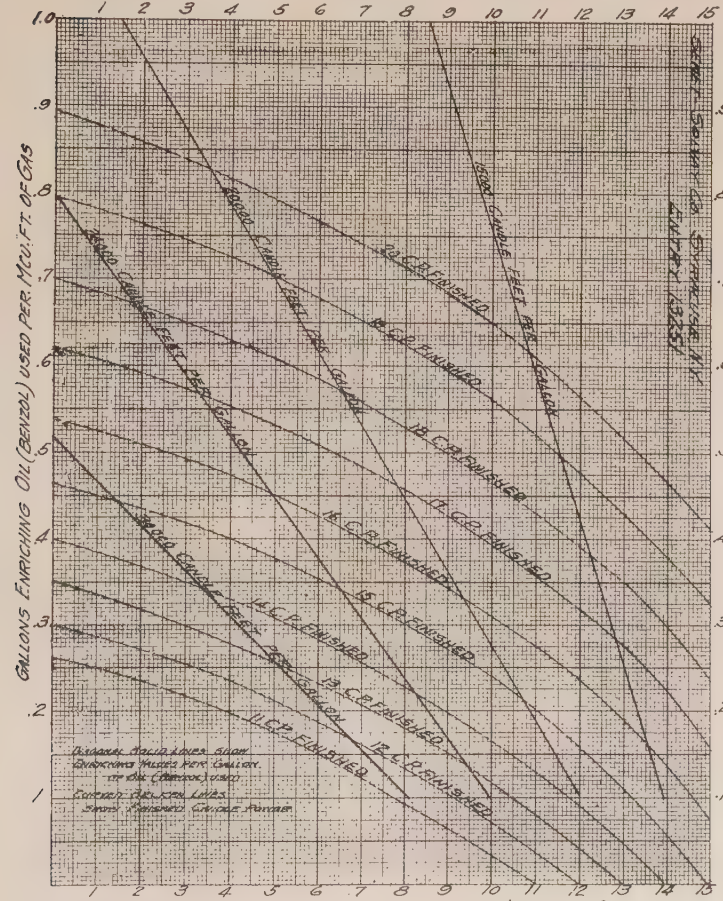

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1.0 .9 .8 .7 .6 .5 .4 .3 .2 .1
GALLONS ENRICHING OIL (BENZOL) USED PER M CU. FT. OF GAS
SCALE SHOWING GAS SAVING IN CANNEL GAS
BASED ON CANNEL GAS
BASED CANDLE FEET PER GALLON
BASED CANDLE FEET PER GALLON
BASED CANDLE FEET PER GALLON

TABLE NO. 1.

Showing candle-power actually produced per unit of benzol retained by gas.[1]

Gallons benzol per cu. ft. of gas	Candle-power Milwaukee	Bunte	Detroit and Chicago
.05		3.0	
.10		4.6	
.15		7.4	
.20	8.0	9.0	
.25	9.8	10.4	12.0
.30	11.4	12.0	12.9
.35	12.4	12.9	13.6
.40	13.4	13.9	14.4
.45	14.3	14.7	15.2
.50	15.4	15.4	15.8
.55	17.4	16.1	16.4
.60		16.7	17.1
.65		17.4	17.8
.70		18.0	
.75		18.5	
.80		19.1	

To illustrate the point which it is aimed to bring out by this chart, assume that it is desired to raise a 10.00 candle-power initial gas to 18.00 candle-power, and that the 10.00 initial candle-power is entirely due to oil (benzol). In other words the initial gas free from benzol is practically blue gas. Chart No. 2 shows that .465 gallons of benzol per M. cu. ft. are required, from which benzol 17,200 candle feet per gallon can be realized. However, if the 10.00 candle-power in the initial gas is made up of 5.00 candle-power due to oils (benzol) and 5.00 candle-power due to true gases (ethylene, etc.), the problem is then to raise 5.00 candle-power due to oil to 13.00 candle-power due to oil. The resulting gas will be composed of 13.00 candle-power due to oil and 5.00 candle-power due to true gases (ethylene, etc.), making a total of 18.00 candle-power. To raise 5.00 candle-power due to oil to 13.00

[1] Table No 1. is identical with chart No. 1.

Table No. 2.

Showing benzol required in gallons per M. cu. ft. of gas to raise known candle-powers due to oils (benzol) to given finished candle power due to oils (benzol).[1]

Finished candle-power produced due to benzol only	Initial candle-power due to oils (benzol)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11	.25	.235	.215	.200	.175	.150	.120	.090	.060	.030	.000				
12	.285	.275	.255	.235	.215	.190	.165	.130	.105	.070	.030	.000			
13	.335	.320	.300	.280	.260	.235	.210	.175	.150	.115	.080	.040	.000		
14	.385	.365	.350	.330	.310	.280	.260	.230	.200	.170	.130	.090	.050	.000	
15	.45	.435	.420	.400	.375	.355	.330	.300	.270	.240	.200	.155	.100	.060	.000
16	.53	.510	.490	.475	.450	.430	.400	.375	.345	.315	.275	.240	.190	.140	.075
17	.605	.590	.570	.555	.530	.510	.480	.455	.425	.390	.360	.320	.275	.220	.155
18	.685	.670	.650	.630	.610	.590	.560	.530	.500	.465	.430	.395	.350	.300	.235
19	.78	.765	.745	.725	.705	.680	.650	.625	.600	.560	.520	.475	.430	.380	.325
20	.88	.860	.835	.810	.790	.765	.740	.710	.690	.650	.610	.565	.520	.470	.420

[1] Table No. 2 is identical with chart No. 2.

candle-power due to oil, chart No. 2 shows .210 gallons of benzol per M. cu. ft. of gas required, from which benzol 38,000 candle feet per gallon can be realized. Thus, in the second case, it is observed that only 45% as much oil is required as in the first place to accomplish what is apparently the same work, namely, to raise a 10.00 candle-power gas to an 18.00 candle-power gas.

It is to be remembered that this example, or any case taken from chart No. 2 as to the amounts of benzol required, is based on the benzol actually found in gases of the stated candle-powers under widely varying commercial conditions.

Some further examples illustrating the use of chart No. 2 may make the varying possibilities of benzol enrichment more thoroughly understood.

Various possibilities for producing 16.00 candle-power gas from 10.00 initial candle-power gas.

Total observed initial c.p.	Initial candle-power due to benzol	Initial c. p. not due to benzol	Gals. benzol to be used per M. cu. ft.	Candle ft. per gallon
10.00	10.00	0.00	.310	19300
10.00	8.00	2.00	.230	26000
10.00	6.00	4.00	.190	31500
10.00	4.00	6.00	.160	37500
10.00	2.00	8.00	.140	42900

Various possibilities for producing 18.00 candle-power gas from 14.00 initial candle-power gas.

Total observed initial c.p.	Initial candle-power due to benzol	Initial c. p. not due to benzol	Gals. benzol to be used per M. cu. ft.	Candle ft. per gallon
14.00	14.00	0.00	.300	13300
14.00	12.00	2.00	.240	16600
14.00	10.00	4.00	.165	24200
14.00	8.00	6.00	.135	29600
14.00	6.00	8.00	.120	33300
14.00	4.00	10.00	.105	38000

The above case of raising 14.00 candle-power gas to 18.00 candle-power may explain some of the widely different results which have been obtained in various works where benzol enrichment has been experimented with, even though no troubles were experienced with deposition of oils after enrichment. For instance, assume that a mixture of equal parts of coal gas and water gas of 14.00 and 22.00 candles, respectively, were yielding a finished gas of 18.00 candles and it were desired to reduce the candle-power of the water gas by substituting benzol enrichment. The measure of the success of the change would, of course, depend on the candles obtained per gallon of benzol. Assume that 14.00 candle-power water gas is made instead of 22.00. Then the enrichment is to be 4.00 candles of benzol added to a half and half mixture of coal gas and water gas of 14.00 candle-power. Upon the composition of the 14.00 candle-power gas as to the ratio of the candle-power due to benzol to that due to true gases would depend the enriching value of the benzol used. From the above table it is seen that this enriching value may vary from 13,000 to 38,000 candle feet per gallon. If the water gas is such that a large portion of the 14.00 candle-power is due to its content of condensable oils, much lower results will be obtained than if a large portion of the 14.00 candle-power is due to true gases (ethylene, etc.). The same is true of coal gas. It is, therefore, very apparent that the quality of the gas to be enriched is of quite as much importance as the quality of the benzol to be used. Aside from the carrying properties of the benzol, the proportions of the candle-power of the initial gas which are due to oils and to true gases are to be considered.

Considering the above figures of the possibilities of benzol enrichment of 14.00 candle-power gas to 18.00 candle-power gas, it is seen that there are opportunities for realizing very cheap enrichment. For instance, in the above case of a half and half mixture of coal gas and water gas, in which the water gas is so made that the mixture contains 8.00 candle-power due to oils and 6.00 candles due to true gases (ethylene,

etc.), it is possible to realize 29,000 candle feet per gallon of enriching benzol.

These conditions show that it is essential in attempting to use benzol enrichment to investigate very carefully the gas to be enriched, and that the process can be a success or a failure dependent on the quality of the gas regardless of the quality of the enriching benzol to be used. It is, therefore, not rational simply to reduce the oil used in water gas machines and substitute benzol enrichment, but very careful work should be done to make the water gas best suited to the conditions. In the enrichment of coal gas alone the same conditions are essential, namely, that to secure the best results from benzol enrichment, those methods should be employed in retort and condensing house practice, by which the maximum ratio of the candle-power due to true gases to that due to oils, will be realized.

Coming next to the carrying properties of benzol, Mr. Earnshaw's article is quoted:

"The commercial success of such enrichment will depend upon the difference in vapor tension. It is evident that an increase in quantity of vapor, and, therefore, an increase in candle-power, can only be obtained by increasing the vapor tension of the hydrocarbons in the gas." (Provided the gas is saturated before enrichment). "If the tension of the enriching liquid is very high, the addition of a small amount may raise the tension of the combined vapors so that the gas will carry the amount of vapor necessary to give the desired increase in candle-power. In this case the full enriching value of the added vapor is developed. If the vapor tension of the enriching liquid is but little higher than that of the vapor already present in the gas, then the desired enrichment can be obtained only at considerable cost and the full value of the enriching liquid can not be utilized. Enough of the benzol must be added to bring the average vapor tension up to the required point, but as the total quantity of vapor will now be

much greater than the gas can carry, the surplus will be condensed."

This is, undoubtedly, as definite a statement of the facts as can be made and brings out the laws which must be recognized in order to use benzol enrichment successfully.

From a recent study of commercial benzols usually marketed for gas enrichment purposes the vapor tensions are found to be sufficiently high so that the amounts that a gas can retain at reasonably low temperatures (36° to 40° F.) and pressures up to say, 20 or 30 inches head of water, are ample to give at least 16.00 to 18.00 candle-power due to benzol only. This was tested out in actual practice and the gas at the end of a 2-mile transmission under 20 to 30 inches water pressure with a temperature of 35° to 37° F. was found to retain 16.00 to 17.00 candle-power due to benzol only. This gas before enrichment and travel was saturated with an oil mixture of so low a tension that the addition of very high tension enriching benzol could not raise the average tension sufficiently to enable all the oils to be retained. The result was, as Mr. Earnshaw states, that the full value of the enriching oil was not realized because the surplus low tension oils were condensed. However, even under these conditions in which there was deposition of oils in transmission, 18,500 candle feet per gallon were realized throughout winter months under transmission conditions above mentioned.

(Temperature 33° to 37°F.; pressure 20 to 30 inches water). The gas was 10.00 candle-power initial enriched to 17.50. The initial gas carried 8.00 to 9.50 candles due to benzol and, therefore, the enriched gas after transmission carried 15.50 to 17.00 candle-power due to benzol only.

A study was also made of the condensates in the pipe lines. This examination confirmed the above statement which was based on examination of the oil mixture present in the gas before enrichment and the enriching benzol used. That is to say, the major portions of the condensates were low tension oils that had been present in the initial gas and not in the

enriching benzols used. It is, therefore, apparent that if the oils present in a gas to be enriched are of as high vapor tension as ordinary commercial benzols, 16.00 to 17.00 candle-power due to benzol can be retained without loss under transmission conditions, as above outlined.

Along this same line it can be predicted that if gas of a higher illuminating power not due to condensable oils, is to be enriched, sufficient benzol can be carried to produce 16.00 to 17.00 candle-power, even if the oil present in the initial gas is of a little lower tension than that of ordinary commercial benzol. The above case, which describes the delivery of 16.00 to 17.00 candle-power due to benzol shows some loss in transmission. The fact that this candle-power due to benzol was delivered, indicates that if there had been present in the gas before transmission only benzol of the same quality as that which reached the delivery end, no loss should have been expected.

To substantiate the statement that benzol equivalent to 16.00 to 17.00 candle-power can be carried without loss under transmission conditions as outlined, the practice at Detroit is cited as an example. At this operation by removal from the gas to be enriched of only those oils of the very lowest tension, gas was delivered in the severest winter weather a distance of about 2½ miles under a pressure of 24 to 60 inches of water with practically no loss in candle-power. This gas was of 18.00 candle-power, of which 15.50 to 16.00 candles were due to benzol. The benzol used at Detroit was a so-called high grade oil testing 95% distilling to 212° F. This benzol combined with that present in the initial gas produced an oil mixture of such a tension that 17.50 to 18.00 candle-power due to oil was delivered without any loss.

Ordinary commercial benzol is an oil mixture varying in test from 80 to 90% distilling to 212° F. As the per cent. distilling to 212° F. increases there is a rise in the vapor tension but probably in no definite ratio to the distilling point, owing to the complex mixture of the oils. Therefore, the higher

the grade of enriching benzol used, the higher will be the average vapor tension of the benzol mixture in the enriched gas and, consequently, the larger the benzol content that can be retained per unit of gas.

From the fact that in commercial practice a gas carrying oils of about the nature of ordinary commercial benzol was saturated at 33° F. when the oil content was equivalent to 15.50 to 17.00 candles, it is apparent that if it is desired to increase the candle-power due to benzol, the quality of the oil in the finished gas must be improved. That is to say, the vapor tension of the mixture must be higher. This is possible by using a higher grade of enriching oil or reducing the amount of low tension oils in the gas to be enriched, or by the use of excess enriching benzol and the consequent deposition of the low tension oils by substitution in transmission. These are conditions which must be worked out for the individual problem under consideration. It can not be stated that benzol added to all gases will give certain definite results, but from the above experience with gas having a high candle-power due to benzol it is certainly evident that if the problem is properly worked out in accordance with the physical laws involved. benzol offers opportunities for most economic enrichment.

If it is desired to transmit the gas under high pressures it is essential to have present after enrichment only very high tension oils. For example, a saturated gas of 18.00 candle-power all due to benzol, at atmospheric pressure, carries .7 gallons of benzol per M. cu. ft. If the pressure on this gas is increased to 15 pounds and the temperature reduced to the same point as before compression, the amount of oil carried will be reduced 50%, and the candle-power reduced to about 13.00 if no change took place in the oil mixtures (in practice this candle-power would be higher than 13.00 due to the benzol being a mixture and as the oil is precipitated out there is formed a mixture of somewhat higher tension than that of the original benzol present, so that considerably more than 50% is retained). In order to practice benzol enrichment

before high pressure transmission with minimum candle-power losses, only the very highest tension oils should be present so that the gas is not saturated before compression. If it is necessary to use high pressures for the delivery of any gas containing condensable hydrocarbons, it is practically certain that the increased pressure will decrease the oil content and the candle-power if the gas even approaches saturation before compression.

An example of the gradual loss in candle-power of a saturated gas, due to decrease in temperature, is well brought out in an article by Mr. W. H. Gartley, published in the proceedings of the American Gas Institute, 1906, page No. 603, plate No. 4. With a saturated gas at a constant temperature a similar loss must be sustained with increased pressure for the oil content is in an inverse ratio to the absolute pressure, the same as it is in a direct ratio to the temperature. With increased pressure there is, of course, a tendency to deposit first the oils of the lowest vapor tensions. Therefore, at the low pressure end of a high pressure transmission line the gas is considerably below saturation and contains almost entirely high tension oils and is in the ideal condition for benzol enrichment. For instance, to deliver very high candle-power water gas under high pressure with no rise in temperature, there must be a loss in transmission similar to the loss by reduced temperature, and, in order to have the desired candle-power at the delivery end, a certain higher candle-power must be started with. If, now instead of starting with the necessarily higher candle-power gas than is to be delivered, the gas is enriched with benzol after high pressure transmission, the benzol can be retained to the best advantage. The low tension oils will have been deposited by the compression and the gas is, therefore, in a condition in which it can retain the maximum benzol content. This again is simply an application of the physical laws on which the principle of benzol enrichment is based. The high pressure is an ideal means for removing the low tension oils which would otherwise limit the

effectiveness of the benzol. When these low tension oils are eliminated there should be no difficulty in retaining ample quantities of ordinary commercial benzol for producing reasonable candle-powers which can be retained in low pressure transmission, even in extremely low temperature. Furthermore, if those low tension oils are precipitated out by compression after enrichment they bring down with them some of the high tension oils as well, due to the fact that the separation or fractionating, is not sharp in the gas mains where the velocity is very high.

Enrichment with benzol at the delivery end of high pressure lines is simply a proper application of fundamental principles. By this plan benzol is added under the condition in which it will be retained according to physical laws and under the same condition that it has been found to be retained in actual practice.

It is understood that the results at Chester, Pa., will be presented to illustrate the advantages of this practice.

At Milwaukee benzol is added to the gas after 1½ miles of transmission under about 2 pounds pressure, so that a small portion of the low tension oils have been deposited before enrichment. The gas is then tested 2 miles beyond the point of enrichment. The following operation results may be of interest:

1909 Month	Initial candle-power at ovens	Gals. enriching benzol used per M. cu. ft. of gas	Fin. C. P. after transmission	Candle feet per gallon of benzol
February ..	9.14	.40	17.19	20201
March	9.59	.39	17.40	19876
April	10.02	.42	17.00	16517
May	10.15	.40	17.42	17915
Average ...	9.72	.40	17.25	18627

Enriching values of the oil used there are determined from the candle-power of the gas as it leaves the condensing house at the ovens as compared with the candle-power after trans-

mission, and, therefore, absorb all the loss due to the deposition of the low tension oils. That is to say, the enriching value represents the enrichment of the gas not as put into a holder at the works but of the gas as delivered over 2 miles at a temperature of 35° to 40° F. and pressures up to 2 pounds per square inch. Mr. W. S. Blauvelt has presented the results at Detroit which show that with gas better prepared for benzol enrichment but still carrying a total benzol content about the same as Milwaukee, considerably higher enriching values can be realized and practically no loss sustained in transmission.

It has been aimed in this report to show some of the applications of the physical laws covering the use of benzol as well as to bring out some studies showing the values of benzol that is retained.

A fair consideration of the possibilities of benzol with due consideration of the conditions which affect the retention of this enriching medium bring out very clearly Mr. Earnshaw's conclusion "that every case in which it is desired to use commercial benzol as an enricher, must be treated as an independent and separate problem and considered in the light of known laws."

It is evident that practically no two operations need the same treatment in order to give the most economical results. In one case a small loss in transmission might be more economical than the cost of the removal of the low tension oils at the works, whereas in another case exactly the opposite might be true. Similarly the cost of obtaining the desired results must be balanced one against the other in any case, but the results which have been obtained surely indicate that if properly handled there are opportunities in many cases for remarkably economical enrichment by the use of benzol.

Benzol Enrichment at Detroit.

1. The Solvay Process Company, at their Detroit Works, operate retort ovens primarily for the production of metallur-

gical coke. The coal used yields a gas of comparatively low illuminating power, the richest gas seldom exceeding 12 candle-power. Almost all of the illuminating power is due to condensable hydrocarbons; by washing the rich gas with an absorbing oil its illuminating power is reduced below 2 candles.

2. The surplus gas, enriched with benzol, is sold to the Detroit City Gas Company. The amount of enrichment is varied from time to time at the request of the Gas Company, who may ask for from 15 to 20 candle-power, and may change their requirement as frequently as they choose.

3. At the coke-oven plant the gas is condensed, scrubbed and enriched with benzol; it is then delivered through a 16″ main about 2,300 feet long, under a pressure varying from 13 to 19 inches of water to the purifying plant of the Gas Company at Delray Station.

4. After purification, the gas is pumped, under a pressure varying from 24 to 60 inches, to Station A, a distance of about 2½ miles. For the greater part of the distance the main is laid very near the surface, so that the temperature of the gas varies greatly with the weather; in midwinter often going as low as 25° F.

5. Gas sample holders are installed at the coke-oven plant, Delray station, and Station A; in these holders, gas samples representing 12-hour runs are collected. At the ovens are obtained samples of the gas before enrichment. The official candle-power is determined at Station A, where photometric observations are made by representatives of both companies. The observations made at Delray Station provide a check to determine candle-power losses in the main between there and Station A.

6. The candle-power of the 12-hour holder samples does not always check very closely with the average of 12 hourly candle-power determinations made direct from the line, as the holder sample is seriously affected by the previous samples. For a period of two weeks or longer, however, the

average of a large number of line sample checks very closely with the average of the holder samples.

7. Hourly candle-power determinations are made at the Delray Station, and the results are telephoned immediately to the foreman at the ovens, who varies the quantity of benzol used in order to meet the candle-power requirements of the Gas Company.

8. Before last winter great difficulty was experienced during the severest winter weather in enriching gas to 18 or 20-candle-power at Delray Station and delivering the same candle-power at Station A; when the atmospheric temperature fell there was frequently a loss of as much as 4 candles; when the weather grew warmer the candle-power at Station A would often be 2 candles higher than at Delray.

9. Obviously this irregularity was due to the presence in the gas, after enrichment, of certain hydrocarbon vapors having such low vapor tension that they would condense when cooled to the low temperatures to which the gas was subjected at times, and the resulting condensate would evaporate when the temperature of the gas rose. In view of the fact that of the total illuminating power of say 18 candles, at least 16½ candle-power is due to condensable hydrocarbons, and only about 1½ candle-power to permanent gases, these results were not at all surprising. It was evident that complete success could be obtained only by the elimination from the gas of all hydrocarbons which would condense under the most severe conditions of temperature and pressure to which the gas would be subjected.

10. To overcome the difficulty, the first step was to install an apparatus in which the gas to be enriched is washed with absorbing oil containing from 3 to 5% of benzol. This absorbing oil takes from the gas only the low vapor tension hydrocarbons. A recent test of this oil washer gave the following results:—

	Before oil washer	After oil washer
Grams naphthalene per M. cu. ft. gas	17.32	3.55
Gals. unfractionated, naphthalene-free, condensable oil, carried as vapor per M. cu. ft. gas	.268	.251
Fraction of above oil distilled up to 212° F. Gals. per M. cu. ft. gas	.171	.177
Fraction of same distilled above 212° F. Gals per M. cu. ft. gas	.097	.074
Average candle-power, 18 tests	8.25	8.11

From this test it will be noted that one M. cu. ft. of gas in passing through the washer took up from the washing oil .006 of a gallon of benzol, and gave up to the oil, 13.77 grams of naphthalene and .023 of a gallon of other low vapor-tension hydrocarbons. There is no doubt that, by increasing the capacity of the oil washer, a still further reduction in the quantity of low vapor-tension hydrocarbons carried by the gas, can be made, thus increasing the vapor tension of the hydrocarbon vapors left in the gas and also the capacity of the gas for carrying additional quantities of high-grade benzol.

11. The gas having been prepared for enrichment as outlined above, the next step was to make a high-grade benzol practically free from low vapor-tension oils. This was accomplished by very careful fractionation. The standard adopted for winter use was a benzol, 95% of which distills at 212° F. This grade of benzol freezes at about 32° F.; for winter use, therefore, it must be stored where it can be kept above that temperature.

12. The results after these two changes were fairly satisfactory. Tests in the coldest weather, however, showed that there still remained in the gas, enough of the low vapor-tension hydrocarbons to cause an appreciable loss of illuminating power, when the gas was enriched to above 18 candle-power and afterward cooled to below 32° F. In the following table are given the results of a number of candle-power determinations made direct from the line at Delray and Station A.

TABLE 1.

Tests to Determine Loss of Candle-power by Gas after Enrichment.

Date 1909	Shift	Average atmos. temp.	Delray station			Station A				
			In'l C. P.	No. of tests	Avge. C. P.	Candles enriched	No. of tests	Avge. C. P.	Loss of C. P.	Gain of C. P.
Jan. 8	Day	26.0°F.	8.10	11	17.12	9.02	8	17.22		.10
8	Night	28.5°	7.60	12	17.34	9.74	8	18.31		.97
14	Day	35.0°	7.39	7	18.72	11.33	7	18.36	.36	
14	Night	32.0°	8.70	9	18.77	10.07	9	18.34	.43	
15	Day	27.0°	7.69	7	18.13	10.44	7	16.42	1.71	
15	Night	17.0°	8.12	9	18.57	10.45	9	17.01	1.56	
19	Day	34.0°	9.43	7	18.11	8.68	7	18.81		.70
19	Night	28.0°	9.27	9	18.73	9.46	9	19.86		1.13
20	Day	33.0°	9.28	8	18.80	9.52	8	18.33	.47	
20	Night	35.0°	8.58	9	18.83	10.25	9	19.49		.66
Feb. 1	Day	22.0°	6.97	5	18.77	11.80	5	18.93		.18
1	Night	22.0°	8.85	9	18.99	10.14	9	20.93		1.94
2	Day	33.0°	8.23	7	18.16	9.93	7	19.43		1.27
2	Night	28.0°	8.10	9	18.73	10.63	9	20.06		1.33
3	Day	29.0°	7.27	7	18.11	10.84	7	17.86	.25	
3	Night	31.0°	7.35	9	18.75	11.40	9	18.93		.18

TABLE II.

GAS ENRICHMENT—FEBRUARY, 1909.

Date	Mean atmos. temp. °F.	Initial C. P.	Required C. P.	Average C. P. line Delray	Holder C. P. line Delray	Official C. P. Holder Sta. A.
1	22	7.91	18.00	18.77	19.06	18.52
2	30	8.16	18.00	18.51	19.18	18.24
3	30	7.31	18.00	18.58	17.80	17.68
4	41	7.55	18.00	18.31	17.30	17.00
5	42	7.43	18.00	18.31	16.93	16.94
6	35	7.06	18.00	18.25	17.13	16.76
7	33	8.47	18.00	18.72	18.73	18.63
8	24	7.94	18.00	18.14	17.32	17.00
9	30	6.79	18.00	17.57	16.37	16.74
10	18	7.45	18.00	17.19	16.74	16.50
11	26	8.94	18.00	19.09	18.13	19.27
12	38	8.08	18.00	18.64	18.57	18.39
13	27	7.22	18.00	18.03	17.51	17.03
14	23	6.65	18.00	18.00	17.13	17.25
15	21	6.72	18.00	18.21	17.68	17.34
16	16	6.99	18.00	18.27	18.48	18.17
17	21	7.02	18.00	18.72	18.82	18.42
18	37	7.07	18.00	18.79	19.17	18.93
19	37	7.07	18.00	18.42	18.25	17.62
20	33	6.73	18.00	18.30	18.38	18.10
21	34	7.30	18.00	17.96	17.75	17.90
22	37	7.28	18.00	18.22	18.37	17.37
23	42	7.31	18.00	18.37	18.12	17.99
24	28	7.03	18.00	18.32	18.62	17.30
25	22	6.90	18.58	18.94	19.00	18.52
26	36	8.44	19.00	19.96	19.27	19.88
27	27	8.79	19.00	18.87	18.82	19.08
28	24	9.82	19.00	19.69	19.42	19.20
Aver.	29.8	7.55	18.13	18.47	18.14	17.92

Gals. benzol used per M. cu. ft. of enriched gas, .453.

Candles rise due to benzol added, 10.37.

Candle-feet enrichment per gallon benzol, 22,892.

TABLE III.

GAS ENRICHMENT—MARCH, 1909.

Date	Mean atmos. Temp. °F.	Initial c. p.	Required c. p.	Average c.p. line Delray	Holder c. p. Delray	Official c. p. Holder-Sta. A
1	35	9.64	18.17	18.80	18.87	19.05
2	36	9.70	18.00	18.75	18.91	18.66
3	28	9.88	18.00	18.94	18.37	17.07
4	26	9.90	18.00	18.85	18.72	17.87
5	29	9.06	18.00	19.18	19.27	18.94
6	38	9.27	18.00	19.08	18.50	18.48
7	36	9.09	18.00	18.98	18.51	19.16
8	34	8.79	18.00	18.59	18.63	17.15
9	37	7.24	18.00	18.73	18.22	18.48
10	30	7.22	18.00	18.77	18.20	17.81
11	29	8.88	18.04	18.63	18.59	18.77
12	33	8.64	18.50	19.16	19.24	19.05
13	35	8.90	17.38	18.36	17.55	19.22
14	31	9.08	17.00	18.00	17.83	18.18
15	32	8.90	18.00	18.26	18.00	17.77
16	24	9.79	17.94	18.50	18.05	17.65
17	23	9.50	19.17	18.87	18.68	18.10
18	33	11.05	20.00	20.76	20.12	19.52
19	37	9.11	18.02	18.67	18.63	19.34
20	30	9.65	18.37	18.58	18.74	19.52
21	29	9.83	19.31	19.39	19.42	19.46
22	32	10.17	19.75	19.63	19.42	19.50
23	37	9.92	18.54	18.71	19.13	19.60
24	37	9.46	16.42	17.10	17.70	18.40
25	29	9.67	16.71	17.40	17.90	17.94
26	38	9.07	16.79	17.33	16.97	17.77
27	36	8.88	15.04	15.61	16.48	16.52
28	37	9.00	15.50	16.04	15.91	16.29
29	35	8.48	15.00	15.60	15.22	15.91
30	36	8.48	16.50	16.89	16.94	16.97
31	39	9.30	17.67	17.47	17.74	17.27
Aver.	33	9.24	17.73	18.31	18.21	18.24

Gals. benzol used per M. cu. ft. enriched gas, .372.

Candles rise due to benzol added, 9.00.

Candle-feet enrichment per gallon benzol, 24,194.

It will be noted that the only heavy loss of illuminating power occurred on January 15th, when the atmospheric temperature fell from 32° F. to 17° F.

13. Tables II and III give fairly complete records of the gas enrichment operation during February and March. The candle-power of the gas before enrichment was higher in March than in February, due to slight changes in the oven operation.

14. Average analyses of the enriched gas and the average calorific power are given in Table IV. For each month 16 analyses are averaged. Calorimetric determinations were made hourly and the results given in the table are the averages of all these hourly tests.

TABLE IV.

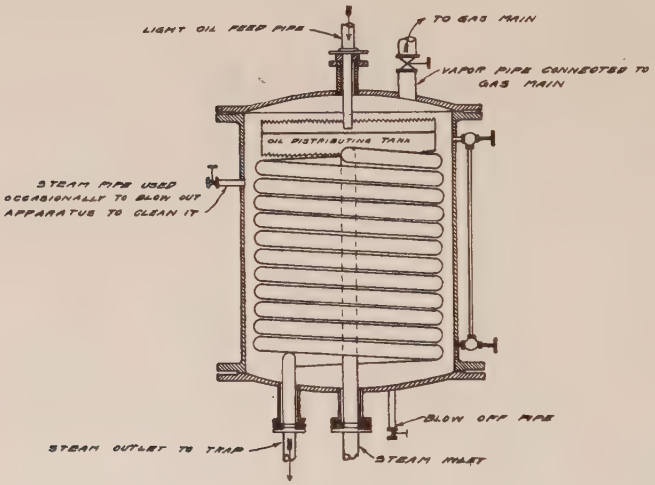
GAS ANALYSES.

	C_6H_6	CO_2	C_2H_4	O_2	CO	H_2	CH_4	N_2	B.T.U. by Junkers Calorimeter
Feb.	1.8	1.4	3.3	0.3	4.7	48.3	35.7	4.5	659
Mar.	1.7	1.4	3.3	0.4	4.7	48.8	36.2	3.5	657

15. Apparently the enriching value of the benzol used, decreases as the total benzol carried by the gas increases. Considering the facts that the total benzol carried by the gas in these two months average about 6/10 of a gallon per M. cu. ft. of enriched gas, that from 14 to 17 candle-power was derived from this source, and that the maximum loss of candle-power under the severest winter conditions was less than two candles, the enriching value of the benzol used was as high as could reasonably have been expected. With an ordinary coal gas of say 15 candle-power, of which say 8 candles are due to permanent gases and only 7 candles to condensable hydrocarbons, higher enriching values should be obtained. Such a gas, if enriched to 18 candle-power, would carry but 10 candles due to benzol, instead of 15, as in the case of the Detroit

coke-oven gas; and under such conditions, lower vapor-tension hydrocarbons could be carried without danger of loss of candle-power due to condensation.

FIGURE 1


LIGHT OIL FEED PIPE
TO GAS MAIN
VAPOR PIPE CONNECTED TO GAS MAIN
OIL DISTRIBUTING TANK
STEAM PIPE USED OCCASIONALLY TO BLOW OUT APPARATUS TO CLEAN IT
BLOW OFF PIPE
STEAM OUTLET TO TRAP
STEAM INLET

BENZOL VAPORIZER

16. The apparatus employed to vaporize benzol is shown in the sketch, Fig. 1. To reduce radiation loss the entire apparatus is covered with magnesia. This vaporizer has a capacity of 100 gallons of benzol per hour when using steam at 25 lbs. pressure in the heating coil. The capacity per square foot of heating surface is approximately four gallons of benzol per hour. In operating the vaporizer, about 2 gallons of tarry oil are drawn off the bottom for every 400 gals. of benzol vaporized. After vaporizing about 60,000 gals., it is generally necessary to remove the coil and clean off the carbonaceous matter accumulated thereon. In order to avoid interruptions to the opening, a square vaporizer is provided.

Use of Benzol for Enriching Water Gas.

The following figures were supplied by Mr. S. R. Walker, Superintendent of the Orange County Lighting Company, Middletown, New York. They give the comparative results of operation during two winters, 1907 and 1908, on carburetted water gas, and 1908 and 1909, when benzol was used to enrich the carburetted water gas.

	1907 — 1908		1908 — 1909		
Month	Oil per M.	C. P.	Oil per M.	Benzol per M.	C. P.
Dec.	5.0	21.1	4.02	.096	21.5
Jan.	4.8	21.4	4.16	.110	21.8
Feb.	5.1	20.9	4.18	.110	22.0
Mar.	4.8	21.2	4.03	.124	21.0
Totals	19.7	84.6	16.39	.440	86.3
Averages ..	4.9	21.1	4 10	.110	21.6

(Signed) V. F. DEWEY.
WARREN S. BLAUVELT.

Since the foregoing report was completed, the following tests have been made on the oil washer:—

	Date	
	June 3, 1909	June 9, 1909
Gals absorbing oil fed to washer per M. cu. ft. gas	1.25	2.54
Per cent. benzol in oil feed	4	..
Temperature of gas entering washer	75°F.	73°F.

	Before washer	After washer	Before washer	After washer
Grams naphthalene per M. cu. ft. gas	23.41	6.61	30.34	19.73
Gals. unfractionated, naphthalene-free oil carried as vapor, per M. cu. ft. gas	.244	.239	.203	.172
Fraction of above oil distilled up to 212°F. Gals. per M. cu. ft. gas	.158	.188	.139	.135
Fraction of above oil distilled above 212°F. Gals. per M. cu. ft. gas	.086	.051	.064	.037
Candle-power of gas, av..	8.67	8.51	6.32	6.21
Candle-power of debenzolized gas, i. e., gas from which all illuminants soluble in oil have been removed				.45

In the course of the test of June 9th, a portion of the gas was passed through a series of vessels containing an absorbing oil. The candle-power of the resulting debenzolized gas varied from .36 to .64, the average being .45.

WARREN S. BLAUVELT.

Chester Operation.

At Chester, Pa., the Suburban Gas Company operate water gas plant and by-product coke-oven plant. The coke-oven plant is situated about a mile and a quarter from the water gas plant, so that the coke-oven gas has that travel before being mixed with the water gas. At the present time all of the gas evolved from the coal charged to the ovens is turned over for distribution to the consumers, the gas required for heating the oven flues being derived from an independent producer installation. This method of operation together with the general system of oven charging employed is productive of widely varying results from the standpoint of quality of gas

received. As an illustration of this point, the candle-power will vary from 17.0 immediately after charging to 1.0 candle-power toward the end of the coking period, the heating values varying approximately between the limits of 650 B. T. U. to 550 B. T. U. per cubic foot. This fact will in itself, I believe explain some of the variable results obtained with benzol enrichment. Another feature in the operation is the presence of water gas in varying proportions in the mixture to be enriched.

The gas from the coke-ovens after its travel through a 10" main 1¼ miles long is metered ahead of the purifying boxes and before being mixed with the water gas. The two gases are mixed in the boxes. The candle-power of the water gas, when same is to be mixed with the coke-oven gas is carried at approximately 20.0. This value was determined upon after experimentation as being the best economic benzol results on the mixed gas. Attempts to carry it below 18.0 c.p. gave very poor results. This value (20.0) allows for one or two candles enrichment from the water gas, the same depending on the ratio of the mixture which in turn determines the c.p. to be delivered to the consumers. We have had no considerable amount of experience with benzol enrichment on straight water gas, except in the months of April and May, 1908, during which time we obtained an average of 21.900 candle-feet per gallon benzol. The process was discontinued, however, on account of the poor carrying qualities of the water gas so treated.

To return to the original description. After being mixed in the boxes the gas is enriched with benzol. The carburetter used is a simple type, the oil being vaporized by steam.

Candle-power readings are taken hourly on the gases before and after enrichment. The finished candle-power is read directly from the line at the outlet of the governors. This allows for a certain amount of condensation between the carburetter and this point, the major portion probably taking place in the holder inlet-pipe and the commercial holder itself.

It is a very noticeable fact that enriching values vary considerably, due to this phase of the operation. During the winter months there is a considerable amount of condensate which gathers on top of the water in the holder tank which vaporizes during the warmer weather and practically automatically enriches the gas. This means that after enrichment there are present in the gas certain hydrocarbon vapors of such low tension that condensation of same takes place when the gas is chilled in the holder, this condensate revaporizing when the temperature of the gas increased to the proper point for such action to take place. At the time of writing we are experiencing a condition of higher c.p. on the end of a 9-mile H. P. system than at the holder station. The gas being pumped is 100% coke-oven gas, where up to a month ago it was a mixed gas. This condition can be explained in the same way. A comparison of drip oil tests will tend to corroborate this statement, some of the higher tension oils having been condensed in pockets along the line during the winter months. It is quite likely that the coal gas contains a less per cent. of candle-power due to benzol, and more to fixed gases, and for that reason is better able to absorb a greater proportion of the oils in the line than was possible with water gas.

The following table and curves give a survey of the operation for the past six months.

Looking at February and March it will be noticed that the enriching values for these months are identical, as well as the atmospheric temperatures. The carrying capacity of the gas, however, was increased. This may have been due to two causes; first a decrease in per cent. of water gas in the mixture; second, the use of a higher grade benzol (about 82% against 78%).

With April the enriching value per gallon jumped to a high figure, namely 34.100. With this there was an increase of 12° F. in atmospheric temperature for the month. There was

also a further decrease in per cent. of water gas in the mixture. The average benzol consumption per day was less than either February or March, along with lower initial c.p. values, showing that some of the condensate collected in the holder was being revaporized, and enriching the gas. Note also the increased carrying capacity under H. P.

For May a still higher value was realized, this with an increase of 11° F. in atmospheric temperature and a slight increase in the per cent. of water gas in the mixture, over the previous month.

In June the water gas in the mixture exceeded the coke-oven gas, the results showing a decrease in enriching value.

The figures for July show an enriching value of 30.100 candle-feet per gallon, under conditions which closely approximated the operating conditions of the previous month.

C. RODMAN STULL.

Month	Temp. air	Candle-power			Candle feet	Darby C. P.	Drop	Remarks
		W. G.	C. O.	M'x'd				
Feb.	38	20.0	7.6	17.3	18.900	12.7	5.6	
Mar.	38	20.2	8.1	16.9	18.900	15.2	1.7	Less W. G. than in Feb. Better grade L. O.
Apr.	50	19.0	7.0	16.8	34.100	16.1	.7	Less W. G. than March. Note increase in air temperature.
May	61	20.1	8.0	16.8	52.500	16.1	.7	
June	71	20.8	6.5	19.0	27.600	15.2	3.8	Excess W. G. over C.G.
July	74	19.8	6.5	19.0	30.100	17.1	1.9	

H. P. drip oil test			Heating values		
	February	August	W. G.	In C.G.	En. mixed
Up to	202° 36.5%	.6%	619	575	603
	202—212° 60.0%	4.0%			
	212—260° 93.0%	41.5%			
	260—302° 97.0%	70.0%			

THE PRESIDENT: You have heard the Report of the Committee on Benzol Enrichment. What action will you take?

MR. BRADLEY: I move that it be received.

The motion was seconded and carried.

THE PRESIDENT: Does anyone desire to discuss the report or ask any questions?

MR. CARL H. GRAF: I have heard some comment made as to the effect of Benzol on meters. I should like to hear from Mr. Shattuck in regard to that.

MR. SHATTUCK: I have used Benzol enrichment for 3 years, and never found any indication that it was affecting the meter diaphragms in any way.

MR. R. B. BROWN: Answering further, I will say that at Milwaukee we have used Benzol enrichment for several years. We found, first, before we understood how to use Benzol to the best advantage, that heavy hydrocarbon vapors of the lower tension series were deposited to some extent upon the valve seats in the meters, and we had a great deal of trouble from sticky valve seats. Since the results of the more thorough investigation of the best methods of using Benzol have become known and applied, we are getting rid of a large portion of the heavy oil vapors in the gas before the Benzol is introduced. We do not find such troubles any longer, and have never had any trouble with the diaphragms.

THE PRESIDENT: The next thing on the program is the report of the Bureau of Information by Mr. W. A. Baehr, Chairman.

Report of the Bureau of Information of the American Gas Institute for the Year 1909.

The Bureau of Information submits the following report upon the work accomplished during the year 1909.

Up to the time of the meeting of the American Gas Institute in the fall of 1908 thirty-nine questions had been submitted to the Bureau of Information, all of which were disposed of with the exception of questions No. 10, 25, 29, 36, 37, 38, 40, and 41. These questions were carried over into the work of this year, and in addition, to the date of writing this report, the list of questions was augmented from No. 42 to, and including No. 56.

The Bureau of Information for the year 1909 as approved by the Technical Committee was as follows:—

W. A. Baehr, *Chairman*,	J. H. Eustace,
H. C. Abell,	W. C. Morris,
W. S. Blauvelt,	Thos. D. Miller,
C. O. Bond,	A. B. Macbeth,
C. F. Burgess,	H. L. Rice,
R. C. Cornish,	J. M. Rusby,
V. F. Dewey,	R. M. Searle,
Henry L. Doherty,	J. D. Shattuck,
A. H. Elliott,	Geo. H. Waring.

A large membership of the Bureau was provided in order to make the burden on the individual member as light as possible. To make the scope of the Bureau as far-reaching as possible, its personnel was selected so as not only to cover the country geographically, but also to secure the names of men versed in all phases of the business, and to cover syndicates, large companies, and small companies as well.

The work this year was carried on in much the same manner as last year. The method of handling the same was as follows:—

Each accepted question submitted to the Bureau was assigned to some member of the Bureau to answer. This individual

member of the Bureau after receiving the question and making up an answer thereto, either from information at hand, or as the result of experiments thereon, mailed a copy of the question and answer to each of the other members of the Bureau, including the Chairman, each individual member, upon receipt of the same, made such comments as he deemed necessary, all such comments being forwarded to the Chairman. The Chairman thereupon compiled the official answer for the Bureau from the data obtained from the original answer, together with the comments on the same.

In order to carry on the work as expeditiously as possible, the Chairman undertook to pass upon the questions submitted, as to their necessary qualifications, for the admission to this work.

By vote of the Directors last year, it was decided that only those questions should be accepted by the Bureau, which were submitted by a member of the American Gas Institute. In addition to this, it has been the original policy of the Bureau, that no question should be answered which is of an advertising nature, or which would fall within the province of the Consulting Engineer, or which for various reasons such as policy, etc., were deemed as not being proper questions to answer. During the year several questions were received which came under the above category.

No numbers were assigned to these rejected questions, nor was any record kept of the same, in as much as they would only constitute mere "lumber" in the proceedings of the Institute.

The Board of Directors also passed the following resolution at the meeting in New York just prior to the October, 1908, meeting of the American Gas Institute,—"Neither the Board of Directors of the Institute, nor the Institute as a body, make themselves in any way responsible for the statement of fact or expressions of view given out by the Bureau of Information."

It was the intention of the Chairman to submit any ques-

tions upon which he had the slighest doubt, as to the necessary qualifications for admission to this work, to the majority vote of the Bureau. This contingency, however, arose very infrequently.

As soon as an accepted question had been assigned, a copy of the same was mailed to each member of the Bureau, also to the Gas Journals for publication. The idea of this was, that any one in the gas business, or interested in the gas business, might submit any answer-at-large to any questions which appeared in the Journals. Inasmuch as it is universally recognized, that a great many members of the fraternity-at-large have information in their possession, which is not generally known, and which if contributed as an answer-at-large, would form a valuable addition to the literature on the subject, the Bureau had hoped that considerable interest might be taken in the work, and that many answers from this source might be submitted. As an incentive for any one in the gas fraternity to submit answers-at-large, the name of the individual submitting such were published. From the report of the work of the Bureau herewith submitted, it can be seen that this interest has been considerable, and the Bureau hereby wishes to express its thanks to the gentlemen who have contributed such answers.

When the Bureau made up its final answer to the question, it forwarded this answer, together with any answers-at-large which might have been received, to the Gas Journals, and these were duly published.

In order that the work could be carried on successfully, it was necessary to count on the co-operation of the Journals in publishing questions and answers as they were received, and other notices pertaining to the work. The Bureau wishes to extend its thanks to the Gas Journals for their valuable and hearty co-operation in this work.

Upon looking over the following report it can be seen that a great many questions were of such a nature, as to require considerable experimental work in order that an answer might be compiled. The Bureau wishes to report that considerable

such experimental work has been done in making up some of the answers, and a great deal of credit is due to the gentlemen who undertook the same. It might be added that the individual members of the Bureau of Information have done a great deal more work in connection with this portion of the activity of the American Gas Institute than would appear from a mere inspection and reading of the report. It is easy to submit questions which require a great deal of study and work to answer, and it was for this reason that the membership of the Bureau was increased to eighteen members. This was necessary in order to prevent any one member from being over-burdened with work.

During the year it was suggested by a member of the Bureau that the answers as finally submitted by the Bureau of Information, be printed as a part of "The Bulletin of Abstracts," properly classified, to go in with the regular classification of these Abstracts.

The above matter was referred to Mr. R. B. Brown, Chairman of the Technical Committee, and upon his advice it was submitted to the majority vote of the Bureau. From the replies which were received from the individual members of the Bureau, only three were in favor of the above proposition. Since the majority of the members of the Bureau were opposed to the above plan it was decided to let the matter drop.

In conclusion the Bureau wishes to thank the Fraternity for the interest shown and assistance given in this work, and begs to herewith formally submit this report.

Respectfully submitted,

W. A. Baehr, *Chairman*,
H. C. Abell,
W. S. Blauvelt,
C. O. Bond,
C. F. Burgess,
R. C. Cornish,
V. F. Dewey,
Henry L. Doherty,
A. H. Elliott,
J. H. Eustace,
W. C. Morris,
Thos. D. Miller,
A. B. Macbeth,
H. L. Rice,
J. M. Rusby,
R. M. Searle,
J. D. Shattuck,
Geo. H. Waring.

(Note: The Questions and Answers are given in full in the Appendix).

THE PRESIDENT: You have heard the Report of the Bureau of Information. What action will you take?

The motion was made, seconded and carried that the report be accepted.

MR. MCILLHENNY: I think we ought not to accept this report in a perfunctory way and say nothing about it. A great deal of work has been performed by the Committee and we should have a little more public expression on the matter. The Committee is a very valuable adjunct to the Institute, and the more its services are realized, the more valuable it will be. When the members realize that they can write at any time for information about problems confronting them, they will feel that it is an important feature of the Institute.

THE PRESIDENT: The next is the report of the

COMMITTEE ON UTILIZATION OF GAS APPLIANCES,

by Mr. W. J. Serrill, Chairman. In the absence of Mr. Serrill Mr. Forstall will read the report.

Mr. Walton Forstall then read the report as follows:

REPORT OF COMMITTEE ON UTILIZATION OF GAS APPLIANCES.

The Committee having been recently appointed, this report is necessary a preliminary one. Gas consuming appliances, excluding those used to give light, may be divided into three classes:

1st, Industrial appliances.
2nd, Cooking appliances.
3rd, Water Heaters.

(1) Industrial appliances have had a large development in recent years. Special designs have been made to meet special requirements, until practically all processes in the arts that require heat may be carried on by the use of gas

Obviously, no attempt need be made to standardize the construction of appliances belonging to this class. The extension of the use of these appliances among its consumers should form an important part of the activities of every gas company. The Committee will consider the establishment of a plan by which a knowledge of new appliances designed to meet special needs, may be gathered from various sources and furnished to the members of the Institute.

(2) Cooking Appliances: The construction of the more usual forms of cooking appliances has become sterotyped in the general features, but still exhibits many variations in details, among the various manufacturers, and from season to season. The advantages to both gas company and manufacturer, in the adoption of a standard design, which would be practically unchanged from season to season, are obvious. The objection that is sometimes raised that the adoption of a standard will tend to discourage invention or improvement, the Committee does not consider to be a serious one, believing that it will not shut the door to any real improvement. The subject is full of difficulties owing to the special requirements of different localities, but the Committee will give it serious consideration. As a means of eliciting suggestions, the specifications in use by two large purchasers of gas ranges, are enclosed as exhibits in this report. The principal points of difference, brought out in those specifications, are:

1st, Sheet steel vs. cast-iron, front and top.

2nd, Loose cap vs. one-piece cored top burners.

3rd, Air space vs. sheet asbestos, insulation in ovens at sides and back.

4th, Front (open door) vs. side, pilot lighting for oven burners.

5th, Lever handle cocks vs. needle valves.

6th, Fixed orifices, drilled in removable spuds vs. adjustable orifices.

The members are urged to send suggestions on these, and

other, points in the specifications to the chairman as soon as possible after this meeting.

(3) Water Heaters: The satisfactory solution of the problem of heating water in dwellings is important, for on it depends to a large degree the extension of gas cooking. The varying requirements of different localities, with different climates, makes any uniform solution of this problem a difficult one. One direction in which investigation may prove valuable, is in the development of a thermostatic control in the ordinary combination of circulating heater and kitchen tank, so that a certain quantity of hot water is always on hand, and a comparison of the operating cost of such an arrangement with that of the circulating heater and tank without the thermostat, wherein the water is heated only as needed The specifications of two large users are enclosed as exhibits. Suggestions are solicited.

Respectfully submitted,

W. J. Serrill, *Chairman.*
J. C. D. Clark.
G. D. Roper.
W. J. Clark.
E. G. Van Wie.

Exhibit "A."

Specifications for Gas Ranges.

Top Burners.

Drilled burners with raised apertures, loose caps resting on ground surfaces. These surfaces protected from drippings by shed projection on cap on outer edge, and thimble in centre cast onto cap, and extended below burner bowl with edge beveled to properly dispose of drippings.

Burners to be rigidly supported without bolts or screws, and easily removed.

One giant, three regular, one simmer burner for stoves with 18-inch ovens. 20 and 22-inch oven stoves, two extra regular top burners and one extra simmer burner.

Burners and valves arranged equidistant.

Valves.

Valves having independent adjustable gas apertures only to be used. To be rigidly braced so they cannot be turned in manifold.

Manifold.

Made-up manifold preferred.

If tapped pipe manifold is used, it must be extra heavy and not less than ¾-inch size.

Supply pipe for top burners should rise at back of range so as to take their supply before the oven burners.

Manifold to be tested at factory and be gas tight without calking under not less than 10 lbs. pressure.

Oven Doors.

Counter-balanced drop doors without catch, or spring balanced drop doors with friction catch.

Where steel spring shield is used, same should be not less than 18-gauge.

Ovens.

Insulation not less than ¼″ dead air space with corrugated sheet asbestos lining on all sides and back, and next to outer wall of stove. Linings to be secured in position without bolts or screws, and so arranged that they are easily removed.

Meat ovens 12-inch high preferred.

Oven Burners.

Drilled line burners supported without bolts.

Mixers which can be removed or opened wide for cleaning, and equipped with shield that can be rigidly set when in use.

Simple oven lighting device necessitating opening the oven door for lighting, and oven arranged so that oven burners can be easily seen.

General Construction.

All ranges must be manufacturer's standard type of appliances. In other words, your best.

Flue opening in top plate 4 inches in diameter, fluted and drilled for pin to hold flue pipe.

Top grate openings as large as possible, especially from front to rear.

Feet of stove detached.

Standard 18-inch oven ranges to weigh not less than 160 lbs.

Body corners to be braced. One-piece cast base and cast top.

All parts to be arranged symmetrically to produce a pleasing substantial, plain finished appearance.

Nickel plating to be heavily nickeled, and steel parts to be smooth and uniform color.

Castings to be smooth and plain, properly proportioned for strength.

Exhibit "B."

1910 Gas Range Specification 1910.

1. Body.

The fronts, tops and leg bases of all ranges to be preferably of cast-iron; if made of sheet steel, the metal to be not less than No. 18 gauge (U. S. Standard). Ornamentation to be plain and simple. No leg base to extend around the range. Outside sheet of body to be one piece, and to extend from the leg base to the main top. Linings to provide ½" air space insultation to the ovens at sides and back, without asbestos. Linings to be easily removable and to be held in place without bolts or clips. Bolt holes in castings to be circular and not slots.

The sub-top or burner-box to be of galvanized sheet steel, or of cast iron; to be turned up to meet the main top; and not to be bolted in place.

2. Ovens.

Ovens of single oven ranges to be not less than 11" high; a height of 12" is preferred. The same rule applies to the baking ovens of double oven and cabinet ranges. The broiling ovens of double oven and cabinet ranges to be not less than 9" high.

Ranges which have both ovens elevated and placed over the top burners, to have baking ovens not less than 11″ (preferably 12″) high, and broiling ovens with a clear space of not less than 5″ from the bottom of the broiling burners to the oven floor. Ranges which have only the broiling ovens elevated and placed over the top burners, to have the broiling ovens not less than 9″. Auxiliary baking or broiling ovens to be not less than 9″ high.

3. Oven Tops.

The outside part of the tops of baking ovens on elevated and cabinet types of ranges to be preferably of cast-iron; if of sheet-steel, to be not less than No. 18 gauge (U. S. Standard). The inside part of these tops to follow the regular construction as in ranges where the top burners are over the oven.

The tops of separate elevated broiling ovens to be made in two parts. The inside part should be made of not less than No. 18 gauge (U. S. Standard) sheet-steel and perforated to allow the products from the burners to escape through it. The outside part should be made of two pieces not less than ½″ apart, with a mineral wool or similar insulating material between them. None of this material to be exposed. This material to be tightly enough packed to keep it from shifting and giving an uneven protection. The inside sheet of the outside part to be made of No. 18 gauge sheet steel, while the outside sheet may be either cast-iron or not less than No. 18 gauge (U. S. Standard) sheet-steel. Cast-iron is preferable. This outside part to be bolted together and handled as one piece.

4. Oven Bottoms.

In ranges where a broiling oven is located immediately beneath the baking oven, the baking oven bottoms to be double, with insulation between the sheets, of asbestos or similar material. This insulating material not to be exposed. The sheet-metal to be used in these bottoms to be not less than No. 18 gauge (U. S. Standard) sheet-steel. In ranges where there is no broiling oven immediately beneath the baking oven, the upper part of the baking oven bottom (above the burners)

to be of the same construction as just specified; the lower part (under the burners) to be, if next to the floor, of two galvanized steel sheets, separated so as to give air space insulation and so fastened together as to be handled as one piece, and to slip into place; (the temperature, as shown on a blackened bulb thermometer laid on the floor under the range, should not exceed 120° in 40 minutes); if elevated, so made that it is air tight, bolted in place, and of either cast-iron or galvanized sheet steel.

The bottoms of broiling ovens to be made as just specified for the lower part of baking ovens.

5. Rack Supports.

Rack supports to be made of channel construction to prevent racks from tilting when partially withdrawn. Each set of supports preferably to be formed of one piece of sheet-steel. One support to be placed so that the bottom rack in the baking oven is 1¼″ above the oven bottom; another support to be placed midway between the lower support and the oven top; the other supports to be appropriately spaced. In broiling ovens, the supports to be as close together as possible throughout the height of the oven.

6. Sheet Metal.

No parts made of sheet-steel (or iron) to be less than No. 24 gauge (U. S. Standard). Heavier metal to be used where specified. All to be of black sheet-steel except sub-tops (or burner boxes), range bottoms, drip pans and bottoms of elevated broiling ovens. When the sheet-steel is galvanized, the black sheet to be No. 24 gauge before being galvanized. The outside body is the only part of the range which may have a japan finish.

7. Flues.

The flue-back to be of cast-iron. The collar for flue connection to be on the top of the range, and to be so ventilated that the placing of a vessel over the collar will not prevent the oven products from escaping.

8. Doors.

Swing doors to be hung on pins, which are set in the door lugs when same are cast; and tops of lugs to have a smooth finish.

Door catches to be so designed that any pressure on the door from within the oven will cause it to open.

Swing doors to have the hinges on the side of the range opposite to the oven burner cocks.

Drop doors, when over 6″ in height, to have a spring or a counter-balance. Baking oven doors either to be insulated or to have a smooth cast-iron inside surface coated with aluminum paint.

Broiling oven doors to be so ventilated as to admit an ample supply of air to the broiling oven, and to make it possible to observe the burner flame through the vent holes.

9. Legs.

Legs should raise the lower edge of the leg base at least 2½″ above the floor. The four legs to be interchangeable.

10. Oven Burner Plates.

To be made with collar deep enough to engage the oven lining; and lining to be cut to fit the collar neatly. To have a slot where each oven burner enters, to engage the rib (or web) on the burner, thus preventing same from being set wrong side up.

11. Bolts.

No bolts or screws to be used except those having standard stove-bolt threads. Door linings, knobs, handles and name-plates to be attached by through bolts with nuts, and not by rivets. The bolts and nuts holding the knob or handle and name-plate on the door to be accessible without the removal of the door lining.

12. Top Grates.

Top surface to be raised slightly above the level of the main top; edges to be gradually beveled to where they meet the main top, so that a vessel will slide on or off without jar.

Arms to be so spaced as not to come over the gas outlets of top burners. Top grates to be interchangeable, two pieces preferred.

13. Top Side Shelves.

To be interchangeable.

14. Top Burners.

Burners to be cored castings, and not to have any loose parts. This applies to simmering as well as to other burners. The gas outlets to be drilled ports. No cone spreader to be used. Top burners not to be bolted to their supports, unless the supports lift out with the burners. No supports to be bolted to range. Supports to be interchangeable. The supports to be such as will keep the burners permanently at even distances below the top grates. The distance between the tops of burners and the bottom of a vessel placed on the top grates to be not less than 1¼".

The simmering burner to be so located that its combustion will not be hindered by nor interfere with the combustion of any other burner.

The simmering burners on cabinet ranges not to be located on same side as ovens.

15. Oven Burners.

To be easily removable, and not to be bolted or locked into their supports by any means except such as may be necessary to prevent their displacement in shipping.

The gas outlets to be drilled ports.

Each burner to be constructed with projecting rib at mixer end to engage slot in oven burner plate.

Oven burner supports at far end to be of cast-iron; to be bolted to rack support, or oven lining, and not to range body.

Provision to be made for the observation of the oven burner, in single oven ranges, without opening the oven door.

When two or more burners are used on a range, they are to be interchangeable.

Separate broiling burners not to be placed in the same oven with the baking burners.

16. Oven Pilot Lighters.

A type that lights at the side of the range is preferred. The gas is to be fed to the lighter through a separate cock; there is to be a fixed mixer; and the pilot burner is to be a one-piece cored casting, drilled, sawed or milled so that, when it is lighted, it burns with blue flames. Arms of the pilot burner to reach both of the oven burners, and the ports to be so close to ports in the oven burners, and arranged at such an angle, that the lighting is positive, and that the pilot burner will relight from either of the oven burners. The outer end of the pilot burner, whether it is arranged to be lighted from the side or from the front of the range, to project in such a manner, and to have ports so arranged, that when the pilot is burning the flames in these ports can be plainly seen without stooping. This projecting end to be so distant from the pilot mixer that there is no danger of the pilot lighting back.

17. Air Mixers.

Air mixers for top and oven burners not to be separate castings, but to be cast with the burners. To have flat faces, machined off, and fitted with flat-faced close-fitting shutters, to be attached by 3/16" stove bolts.

The shutters themselves to be of substantial cast or malleable iron, or not less than No. 20 gauge (U. S. Standard) sheet-steel. Shutters for top burners, and sheet-steel shutters for oven burners, to be nickel-plated.

18. Cocks.

The gas way to the burners to be controlled by quarter-turn cocks, which are to be made strictly in accordance with the drawing here shown. All dimensions on the drawing are important; cocks which do not conform to them in all respects will be rejected. The brass used in the cocks should conform as closely as possible to the following mixture: 68% of copper, 19% of zinc, 12% of lead and 1% of tin. No scrap material to be used in the mixture. A sample cock will be furnished on request. Handles of top burner cocks to be separated from the front of the main top by ample space to allow of

the operation of the cocks without pinching or burning the fingers. All cock handles to rotate in a horizontal plane.

19. Gas Rails.

Gas rails to be not less than ¾" and all ends to be carefully reamed on the inside to remove the obstruction or burr caused by cutting.

Gas rails not to be constructed of bent pipe.

Rail supports to be of split instead of solid pattern.

The oven rail and the cock to be on the operator's right hand when facing the range. To be two supports for the oven rail. Oven rail supports to be so designed that by removing caps from them, the rail may be swung outward, without removing the bolts that hold the main part of the support to the side of the range, and without straining the oven cocks. The riser from the oven rail to be located at the back of the range. The top of the riser to terminate with a ¾" x ⅜" x ¾" tee instead of an ell, the horizontal rear opening being fitted with a plug.

20. Drip Pans.

Drip pans under the top burners to be galvanized; to have the four edges turned up and the corners made tight; to be of ample length, breadth and depth to catch and contain anything spilled through the top grates; not to bind on the sides of the burner box; and to have handles.

21. Oven Racks.

To be two oven racks of light, strong and durable construction, preferably of the double reinforced type. Oven racks and broiling pans to lie perfectly flat, both before and after the oven is heated, and not to bind against the rack supports.

22. Elevated Ovens.

Air supply to elevated ovens to be taken in at back or sides, so as to avoid as far as possible the drawing in of products from the top burners.

23. Cabinet Ranges.

A tee to be placed in the oven gas rail between the back

burner cock and the back of the range. This tee to have its opening down and to give the same location for the gas riser as with an ordinary single or double oven gas range.

Provision to be made on these ranges for connection at either end.

No piping to be located or run under the supporting frame of the range. The supporting frame to be made of 2" x 1" tee or 2" x 1¼" x ¼" angle section steel and to be built of even heavier material if necessary to keep the range from bending or sagging under any conditions.

Exhibit "C."

1910 Water Heater Specifications 1910.

1. Capacity.

Heaters submitted for test to be adjusted to burn fifty (50) cubic feet per hour, and have a maximum capacity of at least sixty (60) cubic feet per hour at twenty tenths inches of water pressure.

2. Jacket.

The jacket, or outside shell of heater, to be of cast iron and to consist of four main parts, as follows:

One top casting,

One back jacket casting,

One front jacket casting or door,

One base casting.

Ornamentation to be of attractive but simple design.

The top casting and the base casting to be attached to the back jacket casting by through stove bolts with nuts, which are to be so located as to make all of the bolt heads and nuts easily accessible.

The back jacket casting to have two lugs cast on one edge, to engage the lugs on the front casting, or door, and support same; and to have suitable door catch on the opposite edge.

The front jacket casting, or door, to extend the full length of the heater and not to be permanently attached to the other

parts of jacket, but to have lugs and pins, and to be used as a door for lighting the burner, cleaning the inside of the heater, etc.

The lugs on the door casting to set between the lugs on the back jacket casting, and drive pins to be used for holding same.

The door lugs at top to be longer than the door lugs at bottom, so that door will swing open when unlatched. A suitable handle with a positive catch to be attached to the door casting by a through stove bolt with nut. To insure the proper freedom in operating the handle, the door casting should be tapped to receive the bolt holding same, the nut on the bolt acting simply as a lock-nut.

Provision to be made for observing the flame of the burner without opening the door. This provision preferably to consist of a small cluster of holes in the door casting, so arranged that there will be no possibility of mistaking them for lighting holes.

The jacket preferably to be of as small an over-all diameter as is allowable for the proper combustion of the burner and arrangement of the water carrying parts.

3. A Distinctive Name and Size Number.

A distinctive name and size number should be plainly cast on the outside of the door casting.

4. Flue Connection.

The top casting to have an oval or circular collar for flue connection, cast on the top, and set to one side, toward the back, so that the flue when connected will clear the water pipe. The opening in the collar, if oval, to be as shown on the drawing. If round to be of such a size that a 3″ flue pipe can be used. This collar to be so ventilated that when no flue connection is used, the placing of a vessel over the collar will not prevent the escape of the products of combustion.

5. Insulation.

No insulation, other than the cast iron jacket itself, is required. If air space, asbestos or other insulation is provided, it should be completely covered and enclosed by shells of cast iron, shaped to fit the inside of the front and back jacket castings. These shells should be permanently attached to the jacket casting by through stove bolts with nuts.

6. Water Carrying Part.

If a coil type is used, the inlet or bottom end of the coil, or coils, to be brazed to a cast brass fitting, which should extend through an opening in the back jacket casting, and the top, or outlet, to be brazed to a cast brass fitting, which should extend through an opening in the top casting.

Those parts which extend through these openings to be hexagonal in shape to fit hexagonal openings in the jacket castings, and to be furnished with shoulders to bear against the inside faces of the jacket castings, thus preventing the fittings from being drawn through too far by the lock-nuts specified below.

Each of these fittings to have a female iron pipe thread for water connection, and to have a male iron pipe thread on the same end for lock-nut, holding fitting permanently in place in the jacket casting.

Copper pipe to be used in the coils; this pipe to be seamless, of the best quality, and of not less than No. 20 gauge (Stubs Standard). Coils to be smooth and free from kinks, and when completed, with fittings brazed on, to be subjected to a minimum pressure test of 200 pounds per square inch.

If the water carrying part consists of a series of separate castings, they should be cored brass, or iron, castings with all inlets and outlets tapped with female iron pipe threads; joined together with double male nipples with a hexagonal center; inlet and outlet ends of the made-up water-carrying part to be fitted with nipples of either iron-pipe-size brass or galvanized wrought iron, of sufficient length to extend

through the top and bottom of the jacket to allow of the water connections being easily made. Nipples to be of brass or iron to correspond with castings. Complete internals, with both inlet and outlet nipples attached, to be subjected to a minimum pressure test of 200 pounds per square inch.

If the water-carrying part consists of one casting, it should be a one-piece cored brass, or iron, casting tapped on each end with female iron pipe threads for water connection. The ends of the casting itself to project through the jacket of the heater, or to have iron-pipe-size brass, or galvanized wrought iron, nipples attached to allow of the water connection being easily made.

Complete water carrying part, with nipples, if used, to be subjected to a minimum pressure test of 200 pounds per square inch.

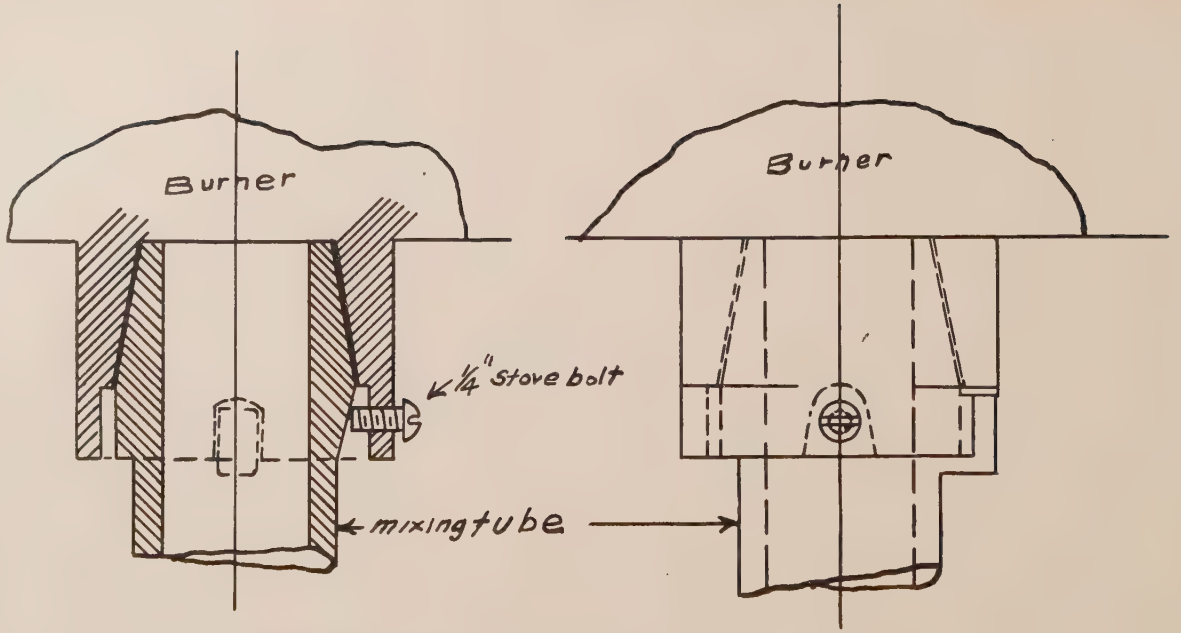
On cast internal type of heaters the jacket preferably to be supported by the internal itself, and to be held in place by two ¼″ stove bolts at top to serve as set screws. Heaters to be so constructed that the relative positions of the water carrying parts, jacket and burner are fixed in regard to each other, so that there is no possibility of their not being put together properly.

7. Burner.

The burner to be preferably a one-piece cored casting with a separate mixing tube. To have drilled ports and to be so designed as to give as wide a variation in consumption as possible with good combustion. To be securely fastened in its position, but not to be bolted in place, and to be easily removable for cleaning, preferably through the door of the heater.

The inlet end of the burner to be ground to fit the ground end of the mixer tube; to be tapped to receive a ¼″ stove bolt to serve as a set screw to hold mixer tube; and to have a slot to engage a rib on the mixer tube to insure its proper location.

The air mixer and tube to be a one-piece cored casting, separate from the burner. To have the outlet end ground



Method of connecting burner and mixing tube

Note:- Sketch shows method and not sizes

to fit the ground opening in the burner; to have a pronounced lug or set for the stove bolt, to insure a permanent, positive joint between mixer and burner; and to have rib or web to engage a slot in burner to insure the proper location of the mixer tube. (See sketch showing method on page 144).

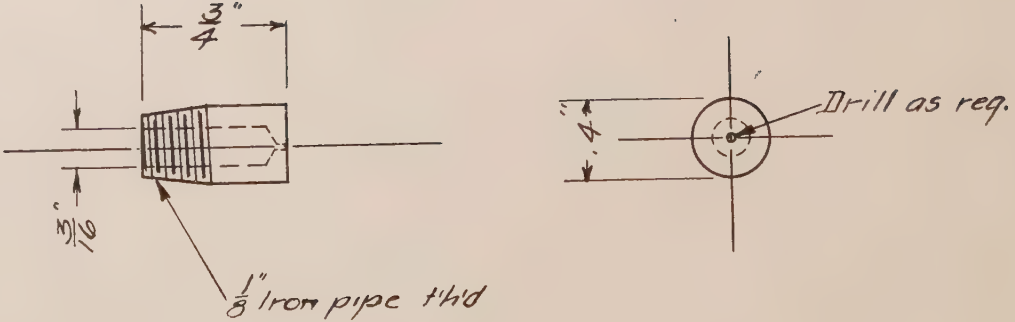
Mixer to have a flat face, machined off and fitted with a close-fitting, flat face air shutter to be held in place by a lock-nut on cock. The shutter itself to be of substantial cast or malleable iron, or of nickel-plated stamped sheet steel of not less than No. 20 gauge (U. S. Standard).

Gauze pillar burners, as described below, will, however, be accepted. A set of (say) six cast iron pillar burners with fixed air supply is preferable. These burners preferably to be of the double gauze type; to have drilled ports in raised lugs, and to slip into place through the door; being held in position by slipping over the spuds or gas nozzles.

The gas-way to the pillar burners to be a cast iron ring firmly bolted to the jacket by means of lugs and stove bolts, and so supported that a sufficient quantity of air will be supplied to the burners. The condensation cup, as hereinafter described, to fasten below this ring. The cock to be as shown in drawing, with orifice spud omitted. The spuds used on the pillar burners to be as shown in sketch.

8. Cock.

The gas-way to the burner to be controlled by quarter-turn cocks, which are to be made strictly in accordance with the drawing here shown. All dimensions on the drawing are important; cocks which do not conform to them in all respects will be rejected. The brass used in the cocks should conform as closely as possible to the following mixture: 68% copper, 19% zinc, 12% lead and 1% tin. No scrap material to be used in the mixture. A sample cock will be furnished on request.


3/4"
3/16"
1/8" Iron pipe thd
Drill as req.
4"

9. Condensation Cup.

A cast iron cup of sufficient size to catch and retain all of the condensation which may form, to be located underneath the burner. Any openings for water or gas supply through to the heater to have a raised edge to prevent condensation overflowing at these points.

Cup to be permanently located at the proper distance below the burner by lugs cast either on the cup or on the base casting and preferably to be supported by the mixing tube of the burner. If supported by the mixing tube, and same is not centered through the cup, but is eccentric, the cup to have a pronounced slot to engage a corresponding web on the mixing tube to insure centering the cup under the heater.

10. Air Supply.

Air for the burner to be taken in at the bottom of the heater and the products of combustion to be properly baffled to give heater its highest efficiency and to reduce flue temperatures to the minimum, without smothering the burner flames.

11. Bolts.

All bolts and nuts used to have standard stove bolt threads.

EXHIBIT "D."

WATER HEATER SPECIFICATIONS.

Burners firmly supported without bolts and easily removable and with loose cap similar to style specified for range top burners. Casing to raise for lighting, or with hinged swing door forming one-half of casing to open for lighting, having friction clasp.

Constructed so that straight water inlet connections can be made to either side of lower section of coil. Heaters to have support from floor to base of heater.

Valves, insulation and flue collar similar to specifications for ranges.

Iron coil constructed to be easily drained, and with smooth openings through coils.

Staggered section of coils to be arranged so that all possible heat will be applied uniformly to each section in turn, and with sufficient circulation in coil to prevent the lodging of sediment in any part of coil.

Water openings to project through heater far enough to provide a suitable hold for a pipe-wrench, and should be tapped ¾″ standard pipe thread.

SIZES: One for 30-gallon storage tank. One for 60-gallon storage tank.

Opening for gas connection not less than ½″.

Flue opening to take 4″ pipe drilled for pin to hold flue pipe.

THE PRESIDENT: What is your pleasure in regard to the Report of the Committee on Utilization of Gas Appliances.

MR. NORCROSS: I move that it be approved.

The motion was seconded and carried.

THE PRESIDENT: Next we have the Report of the

WRINKLE DEPARTMENT,

Mr. F. L. Cross, Editor.

MR. CROSS: I merely wish to say that the report has been printed, and I thank you for the hearty support that has been given me.

(The Report of the Wrinkle Department will be found in the Appendix).

THE PRESIDENT: What action will you take upon this report?

It was moved, seconded and carried that this report be approved, with the thanks of the Institute to the Editor.

THE PRESIDENT: Next we have the report of the

COMMITTEE ON CALORIMETRY,

Mr. J. B. Klumpp, Chairman.

MR. KLUMPP: Mr. President and Gentlemen,—I want to report that the Committee on Calorimetry this year have continued their work begun last year, investigating various calorimeters and methods of operation. The work was con-

ducted at the University of Wisconsin the same as last year, principally by Mr. Kowalke, a member of the committee and a member of the Institute. We went over the work generally and found that the instructions given last year were practically correct; in other words, we have no reason to change the directions there given. We emphasize particularly the selection of apparatus, particularly meters. We call attention to the interior water overflow, which causes trouble and discrepancies. We know of a case where a large sum of money was held up on a contract, because an error of 15 to 20 per cent. was made on the calorific value of the gas due to an error of registration of meter from this cause.

We particularly recommend high-grade thermometers. Get thermometers that are calibrated and standardized, and work them in pairs. Such thermometers can be obtained at $12 to $15 apiece, but you know what you are getting. A cheap thermometer might give a variation of 10 to 20 B. t. u's.

The principal difficulty as to the accuracy of calorimeters in the past has been the temperature of the inlet water. Last year we said that the temperature of the water should be the temperature of the room, and we investigated that subject very thoroughly this year. With the room temperatures at 70° and water temperatures as low as 40° and as high as 90°, we obtained a curve that showed the error for various temperatures. With water at 40° and the room at 70°, the error was as high as 20 B. t. u's. plus; with the water at 90° and the room at 70°, 18 B. t. u's. minus. This curve crosses the zero line at the temperature of the room and flattens out, so that it shows if the water temperature is within 5 degrees of the temperature of the room, the reading should be within one B. t. u. of the heating value of the gas, provided everything else is right. This subject was further analyzed by determining the radiation of the calorimeter and the loss in absorption of sensible heat and the loss in absorption of latent heat. The radiation equalled from 5 to 6 B. t. u's. but the results came within 1 B. t. u. of the correct heating value, when the water was within 5 degrees of the temperature of the room. These

readings are all shown in detail, the curves are shown in the plates at the end of the report, and I think we have made it so plain that everybody will understand.

We made an investigation of the effect of humidity on the calorimeter, and found that in extreme cases there was an error of 4 to 6 B. t. u's.; that is, when the humidity was zero to 30 per cent., the error was as high as 4 to 6 B. t. u's.; but if within 50 to 100 per cent., or normal conditions, the error was within 2 B. t. u's.

We heard of several calorimeters that were being offered on the market, such as the Parr, the Lucke, and Doherty, but were unable to obtain any of them. Last year our attention was brought to the Graefe calorimeter that was in general use. We obtained one from the agents in this country and made a thorough test of it. This calorimeter you will remember allowed the products of the combustion to leave at a temperature so high that it carried off the water formed as vapor. It therefore gives a low heating value, and this heating value depends upon the temperature of the products of combustion discharged. We tested it and found it 50 to 100 heat units out, and always low. We absolutely disapprove of such an instrument; it is cheap, costing only $25, but it gives readings that are in error from 10 to 20 per cent.

Last year the committee recommended you remember, that thermometers be placed on the same level. We have received a letter from the Junkers people in Germany stating that they are now building calorimeters in accordance with this design. They also now make a calorimeter that has provision for cleaning. We found that a very necessary qualification for a calorimeter. After it has been used for about 2 years, it should be cleaned the same as a boiler, the scale of mud should be taken out of the water jacket. If the bottom of the calorimeter can be taken off without unsoldering, it makes it a much more convenient and reliable instrument.

I want to say that the committee still believes that we can get thermometers to read accurately within a tenth of one degree, that we can calibrate our meters to read correctly, and

we can weigh our water or measure it accurately, and get a heating value that will be within about 1 per cent. of the actual heating value of the gas.

We recommend the use of a calorimeter cabinet. This should be built as shown in the report. The calorimeter should always be permanently installed in place with an overhead tank which will allow the water to attain the temperature of the room. In such a cabinet the calorimeter can be located so that it is always ready to use and not interfered with, observations can be readily made inside of 30 minutes, and a satisfactory manipulation of the instrument assured.

REPORT OF COMMITTEE ON CALORIMETRY.

SYNOPSIS OF REPORT.

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Introduction.

In 1907 the first Committee on Gas Calorimetry was appointed by the President of the Institute, and after a year's investigation and experimental work the report of this Committee was presented to the Institute, Oct., 1908.

This Committee, after a complete search of all available literature on the subject, found but little authentic information published that would enable it to draw any conclusions as to the best methods or the best instruments to adopt for commercial practice. It was therefore decided to obtain Calorimeters of various types, and proceed with as thorough an investigation of the Gas Calorimeter as was possible in the limited time at its command. The report of 1908 gave a detailed description of the experiments undertaken and the methods adopted in arriving at the conclusions given. The experimental work with such instruments as were obtainable enabled instructions and precautions being formulated, which were considered necessary in assisting the average operator to a more accurate determination of the calorific value of the gas. The work undertaken at that time brought to light several important points that needed further investigation, to confirm these deductions and conclusions, and to this end the Calorimetry Committee was continued, and further experimental work was undertaken during the past year.

The result of these experiments, and the inferences deduced are appended herewith, and seem to confirm the statements made by your Committee in 1908.

Synopsis—Report, 1908.

To assist the reader of this report, it is deemed advisable to submit a brief synopsis of the work that was done last year, although no attempt will be made to go into details of the work, and for this purpose a copy of the 1908 report should be obtained and carefully studied.

The report presented to the Institute last year covered a

short description of the practice of gas calorimetry in both America and Europe, and gave reasons for the increasing use of the calorimeter as an instrument for determining the quality of a commercial gas. It went into the principles of gas calorimetry, and described the methods of general operation, and the reason for selecting the units of measurement. An investigation of several types of calorimeters was made, and that type embodying the principle of heating a certain quantity of water to a known temperature, was generally approved and adopted as being the most practical method of determining the heating value of a commercial gas.

Four different makes of gas calorimeters were tested, the Junkers, the Boys, the Simmance-Abady and the Sargent. Descriptions and cuts of these instruments were given, showing the methods adopted by the inventors in utilizing the principle of water heating. The instruments were purchased direct from the manufacturers by operating concerns, whose purpose was to use them in daily operation, and they were not specially prepared for scientific investigation. The Committee, appreciating the result of the publication of such an investigation, was exceedingly careful in the selection of a suitable location for its work, the adoption of most carefully calibrated meters and thermometers, which were checked by the best authorities, and also in selecting those operators whose work could be thoroughly relied upon and be unbiased.

Tests were made to determine the best type of meter for measuring the volume of the gas, a suitable type of governor for governing the pressure of the gas, and the most practical method of determining the exact quantity of water passed through the calorimeter. A careful study of the calorimeter proper was made to determine the most convenient and most accurate method of transmitting the heat from the gas to the water, the best type of gas burner to use, and what was necessary in the way of thermometers that would give accurate temperature readings. This question of thermometers occupied a large proportion of the time of the investigation, and

it was only after many calibration tests, that some few thermometers were found, which with proper correction curves were accurate enough to be adopted.

The work of the Committee was then devoted to the very important subject of the water supply. This was found to be one of the fundamental qualifications for accurate work, and the quantity of water to be used, and the inlet temperature and rise in temperature of that water was made the subject of very careful study.

Further tests on the general efficiency of the calorimeter were made, and gave results that confirmed previous investigations in Germany by Dr. Immenkotter, and confirmed the views of the Committee that the gas calorimeter could be made and operated as an instrument of precision.

The operating instructions given in the report of 1908 were compiled after a thorough study of the subject, and they were intended to be concise and explicit, and it was hoped would enable the average works operator to operate a calorimeter with consistent results.

Finally in the report suggestions were made for further investigation. These suggestions covered the work that the previous Committee was unable to carry through, owing to the limited time at its disposal, and it was desired that these determinations should be made, if possible, by continuing the investigation.

The suggestions consisted of, determining the effect on heating value resulting from a difference in temperature between the inlet water and the room temperature, the effect on calorific readings resulting from a varying atmospheric humidity—and a determination of heat lost through the products of combustion leaving the calorimeters above or below the atmospheric temperature.

This work was continued along these lines and these results with those of some further experimental work carried on are herewith submitted in this report.

This Year's Investigation.

This year, as in last, your Committee has confined itself to the investigation of the water heating type of calorimeter, and continued its investigation with some of the instruments previously tested with the addition of some others obtained for comparative purposes.

The investigation has followed somewhat the lines laid out and suggested in last year's report, as being desirable to continue, and results obtained signified the correctness of the deductions then made.

Appreciating that one of the greatest and most frequent causes for discrepancies in results was the variation in temperature of the inlet water from that of the measured gas and surrounding air. A series of experiments were undertaken to determine what this discrepancy was, and then an analytical determination of the individual causes and confirmation of the results.

This investigation is shown in full in the following pages.

The results of this test go to prove the conclusions and instructions given in 1908, that the temperature of the inlet water should be approximately the same as the gas and room atmosphere.

A series of experiments were made to determine the effect of varying the temperature of water at the outlet. This work was of course limited by the capacity of the calorimeter for water, and the rate at which the water could be made to pass through the instrument. The limits of this were comparatively close, and results confirmed last year's investigation.

See plate XIII.

From the observations made in these tests it was apparent that there was some discrepancy in readings, due to the difference in humidity between gas and air supplied and the products of combustion. So preparations were made to vary artificially the humidity of the gas and air delivered to the cal-

orimeter. The result of this test is appended and shows that the error caused by the humidity of the air is a relatively small quantity seldom exceeding a figure that will cause excessive discrepancies in final results.

This observation is directly opposed to results observed in determining the value of a gas by readings of illuminating value which show greatly the effect caused by variations in humidity.

Several calorimeters were obtained by the Committee for the purpose of comparison. These consisted of one other Junker, two instruments of a further improved Sargent type, and a Graefe calorimeter, the last a cheaper article now being placed upon the American market. The detail of these last comparisons are included in the reports as tending to conclude the work of the preceding year.

An investigation was further made to determine what could be obtained in a serviceable thermometer, that would be accurate at all points in the scale and show positively the difference in the inlet and outlet water temperatures; the results of this work is given by a description of these thermometers and a set of calibration curves obtained from a test of a pair received by the Committee.

The investigations of this year were made at the laboratories of the University of Wisconsin and were a continuation of the experiments reported upon by the Calorimetry Committee of 1908.

The conditions of gas supply and storage were identical as before and consisted of taking all samples direct from the city mains supplying the laboratories. These samples were stored in gas holders of 60 cu. ft. capacity each. From these holders the gas was supplied to service line connected to each calorimeter and uniform pressure maintained through a Connolly governor.

Calibration of Instruments.

Because the accuracy of the determination of the heating value of a gas depends so largely on the accuracy of the measuring devices, all water weighing buckets, meters, and thermometers were accurately calibrated before using them to make tests on the various instruments. This was done in every case as was described in last year's Report.

In all the tests of this investigation the quantity of water used for test was determined by weighing in copper buckets. A sufficient number of these buckets to supply each calorimeter were available, and they were all made the same weight so that a common counter-balance could be used. The water weighed on a torsion balance sensitive to 0.001 of a pound in 10 pounds. Each bucket with the inside wet was carefully balanced against the counterweight. This was done to facilitate weighing. Before balancing the wet bucket it was shaken in an inverted position for about 5 seconds to remove the drip.

The meters used in the tests were all calibrated against a ½ cubic foot bottle which had been previously calibrated by weighing the volume of distilled water at 62° F. contained in the bottle. With this device all meters were regulated to an accuracy of 0.05%; each test on the meter consisted in passing 0.5 cubic foot of gas through at the rate to be used subsequently, which necessitated two fillings of the bottle.

The meters were tested under the same pressure and approximately the rate of flow at which they were to be used in the subsequent tests. They were again tested after the investigation was concluded.

All the thermometers used in the tests were carefully compared against thermometers of the University of Wisconsin which had been calibrated by the Bureau of Standards, Washington and the German Bureau of Standards, and correction curves were constructed and used with each thermometer.

Thermometers.

During the past year much time has been given to the study of thermometers for use with the calorimeter.

The calorimeters in past as supplied to the commercial trade were equipped with thermometers, graduated to tenths of a degree, either Centigrade or Fahrenheit, and these thermometers were generally accepted as being correct at all temperatures and no correction factors were used. The careful comparison of many of these with calibrated standards has shown many thermometers to be irregular and inaccurate. When supplied in pairs to measure the inlet and outlet temperatures the error was found to be variable in various parts of the scale, and if the thermometers were interchanged inconsistent results were obtained.

Under these conditions the investigation was conducted entirely with thermometers calibrated through the entire range of temperature, and correction curves constructed for each one.

While it was thought at first this calibration was only necessary for such a close and careful investigation as was being made, the great number of inaccurate thermometers received with such commercial instruments as were obtained, and the resultant error caused by such inaccuracies, has led us to believe that only the best thermometers, and these carefully calibrated, are serviceable for important commercial use.

The methods of calibration were carefully described in last year's report, and the same methods were adopted in the further investigation, careful comparisons were made with the Thermometer No. 4170 of Chemical Engineers Dept. received and standardized by the Bureau of Standards at Washington, in June 14, 1909.

Your Committee has taken up this subject and through arrangements made with Messrs. Hohman & Maurer Co., of Rochester, N. Y., they are now supplying a thermometer that has been built according to its recommendations. The thermometers have a range from 65° to 115° Fahr. and graduated

to 1/10 degree having an auxiliary division at 32° F. which is convenient for carefully checking the ice point. These thermometers are carefully made and have a bore that is exceedingly accurate.

As an evidence of the exactness to which these thermometers may be paired, a set of calibration curves are attached of a test made on two of them, H. M. numbers 122455 and 122456. The curves coincide closely with the certificate furnished by the makers. The test of Aug. 9, 1909, showed a change in the ice point of both thermometers of 1/10° higher than shown in the test of December, 1908. It was, however, noteworthy that the readings of the two thermometers were the same, that they varied together, and the relative readings of the two were unchanged, the variation taking place throughout the entire scale. This change was due to a further aging of the thermometers, for if they had been completely aged there would have been no perceptible change in the ice point.

This fact of thermometers aging signifies that the inlet and outlet thermometers of a calorimeter should be secured in pairs, and used together. If, after a year's use, one should be replaced with a recently made thermometer a change will take place in their comparative readings as the newer one ages.

The error of 1/10° above mentioned may seem to be a small matter, and it is in most measures of temperature, but when the calorific value of a gas of about 600 B. T. U. is determined with a rise of 15° F., a difference of 1/10° means an error of 1/15° of the total heat of the gas or 4 B. T. U., so proportionally to other errors. So when thermometers can be obtained to read accurately within this limit, we recommend them for all commercial purposes.

The errors of determination in reading the calorific value of the gas are not affected in any thing like the extent by the other temperatures taken in observation, such as the temperature of the air, metered gas, and products of combustion,—but the thermometers used at these points should read to de-

grees and be accurate within a fraction of one degree, and should be calibrated as cases have been found where the thermometers were several degrees out.

Arrangement of Apparatus for Tests.

It was evident after the calibrations of the various instruments had been made that certain devices were unsuitable for fair tests of the calorimeter and the calorimeter outfits were therefore arranged so that each would operate under the most efficient conditions.

Water Supply.

The water for the test was taken from Lake Mendota and was clear and free from suspended matter. A tank of about 60 cubic feet capacity located about 40 feet above the calorimeter had a separate supply cock. During the summer this water had acquired the temperature of the atmosphere, while in the winter the water was heated to room temperature before passing into the calorimeter. A very satisfactory heating device consisted of a 5-gallon jar fitted with electrodes and filled with a solution of sodium sulphate, through which alternating currents passed. The solution was agitated continuously with a motor-driven stirrer. A copper tube about ¼ inch internal diameter was wound in a spiral and connected in series with the calorimeter water supply tubing from the main cock on the water pipe. The water supply to the calorimeter in passing through the copper coil immersed in the electrolyte could be heated to any desired temperature and kept at any desired temperature within 0.1° F. by proper regulation of the electric current through the electrolyte.

For each series of tests on the calorimeters the gas tanks were filled with a fresh supply of gas from the city mains and allowed to stand for some time. All tests were run in series which were lettered or numbered and a new series was started with a fresh supply of gas in the tanks.

Comparative tests in different calorimeters were made as nearly simultaneous as possible.

During each series of tests the humidity of the atmosphere was determined by wet and dry bulb thermometers upon which a current of air was directed. The data from each test was recorded on blanks printed for the investigation which greatly facilitated the tabulation and computation.

The Junkers Calorimeter No. 872 of the University of Wisconsin which had been used in the general efficiency tests and whose accuracy had been previously determined by means of an electrical heater, as described in the 1908 Report was used for the comparative readings during this summer's investigation. This instrument had been shown to give results above 99.5 efficiency, and was considered sufficiently accurate for the purpose. This same calorimeter was used in comparative tests with the Junkers Calorimeters No. 571, and No. 1137 which gave almost exactly identical results. It was therefore decided to use Junkers No. 872 in making examinations of some of the finer points of the investigation.

Investigation of Variation in Heating Value Caused by a Difference in Temperature Between the Room and Inlet Water.

In many places where a calorimeter is installed, the water supply is taken directly from the city service mains. In the winter the water is much colder than the room, and this is especially true in a cold climate. In other cases the water supply may be much warmer than the room. The purpose of this series was to determine the error that arises when the water supply is not the same as the temperature of the room.

The Junkers calorimeter No. 872 was again used and the apparatus arranged in all respects like the other tests, except that the supply water passed through a copper coil immersed in an electrolyte. This arrangement permitted the cooling of the water nearly to its freezing point and also heating it to any desired temperature, and holding the water at this temperature for any length of time.

The room temperature was practically constant for it varied only from 68° F. to 70° F., and the temperature of the water was varied from 40° F. to 90° F. The rise in temperature of the water at the outlet of the calorimeter over the inlet in all tests was approximately 15° F. and the rate of combustion about 7 cubic feet per hour, which had heretofore been determined as a satisfactory point of operation.

The results of these tests are shown in Table 13 and Plate XIV (Series X). The heating value gradually decreases as the temperature of the water at the inlet approaches and surpasses the temperature of the room. Below room temperature the curve bends down, and above room temperature the curve bends up. The change in heating value is much slower below than above room temperature. There is a point of inflection in the curve and at that point would be the temperature at which the calorimeter should be operated to get correct results, as is shown in Plate XIV.

Thermal Balance of Tests in Series "X."

The exact point of inflection of this curve is not at once apparent, it becomes necessary to analyze the sources of loss and gain at the various temperatures. If the proper corrections were made at each temperature, the resulting curve should be a straight line, since the sample of gas was homogeneous and the calorimeter constant in its operation. The sources of error to be investigated are (1) radiation or absorption of heat by the calorimeter body, (2) the sensible heat in the air and gas supplied and in products of combustion, (3) the latent heat in the vapor carried by the products of combustion.

1. Heat Absorbed or Radiated by the Calorimeter.

That heat is absorbed from or radiated to the atmosphere by the calorimeter is due to the fact that the water supply entered the instrument at temperatures ranging from 30° F. less than room temperature to 20° F. more than room tempera-

ture. These various amounts of heat are determined by allowing the water to flow through the calorimeter without having any flame inside, but having the combustion chamber and vent for the products of combustion set exactly as in the other tests. The temperatures at the inlet and outlet were then taken and it was observed that when water colder than the air flowed through, the outlet temperature was greater than the inlet temperature, and when the water at the inlet was warmer than the room, the outlet thermometer showed a lower temperature. The average amount of water passed while 0.2 cubic feet of gas could be burned at the rate of 7 cubic feet an hour was 7.339 lbs. Then per cubic foot of gas the total water would be 36.695 lbs. The heat absorbed or radiated per cubic foot of gas burned is therefore the product of 36.695 and the change in temperature. The data and computations are tabulated below:—

Room temp.	Temp. of inlet water F°	Pounds of water passed per cu. ft.	Change in temp. of water F°	B. T. U. per cu. ft.	How disposed
	40.0	36.695	+0.2430	8.92	Absorbed
	53.3	36.695	+0.1044	3.835	"
	59.4	36.695	+0.0792	2.905	"
	70.1	36.695	—0.0036	.132	Radiated
	79.2	36.695	—0.0018	.066	"
	88.7	36.695	—0.0216	.793	"

At 40° F. there are 8.92 B. T. U. absorbed, at 70° F. practically no heat is absorbed or radiated, while at 90° F. there is only about .8 B. T. U. radiated. This curve gives one reason why the water supply should be at the temperature of the room, for then there is a thermal balance.

2. The Heat Balance of Incoming and Outgoing Gases.

The heat balance between the dry incoming and outgoing gas can only be obtained from an analysis of the combustible gas and the products of combustion from which data the air supplied for combustion and the volume of the products of

combustion can be computed. The combustible gas and the air supply bring in a given amount of sensible heat constantly since the gas and air temperature did not vary appreciably during the test. At different stages in this series of tests the products of combustion leave at temperatures different from the respective gas and air temperatures, and therefore heat is either absorbed or radiated, depending on whether the products leave at a lower or higher temperature, respectively, than the incoming gases. The design of the calorimeter is such that the products of combustion are cooled to the temperature of the base of the calorimeter, which is practically the temperature of the inlet water. Since the combustible gas is composed of some hydrocarbon gases whose combustion forms water vapor, therefore a cubic foot of dry combustible gas burned with the required amount of dry air will in general form a smaller volume than the combined volume of incoming gases. If then the incoming gases and the products of combustion, both dry, were at the *same* temperature, the total sensible heat in the incoming gases is still higher than the heat in the products. It is upon these facts that the following computations were based.

(*a*) The Gas Analysis.

The analysis as reported is on the basis of saturated gas at 29 inches of mercury and 68° F. The volume of dry gas in a unit volume of the sample taken is expressed by the equation $V=V_1\frac{h-a}{h}$ where V=vol. dry, V_1=vol. wet, (h)=barometer in inches of mercury, and (a) = vapor tension at 68° F. in inches of mercury. One cubic foot of saturated gas is equivalent, then to $1 \times \frac{29.00-0.68}{29.00} = 0.976$ cu. ft. If the percentage composition of each constituent in the saturated gas be divided by 0.976, the percentage of that constituent in a dry gas is obtained.

The combustible gas had the following analysis:—

Component	% wet	% dry
CO_2	3.90	4.00
Illum.	10.70	11.00
O_2	0.10	0.10
CO	32.30	33.10
CH_4	17.20	17.61
H_2	29.6	30.30
N_2	3.8	3.89
H_2O	2.4	
Total	100.00	100.00

The product of combustion had the following analysis:—

Component	% wet	% dry
CO_2	14.0	14.35
O_2	2.0	2.05
N_2	81.6	83.60
H_2O	2.4	
	100.00	100.00

(*b*) The Air Supplied and the Volume of Products of Combustion.

Since the gas was burned completely, and since the composition is known, the air required for its combustion is easily computed. It is assumed here, for want of more definite information, that the "illuminants" are ethylene C_2H_2. The average humidity of the air supply is 62%.

Gas	Cu. ft. vol.	Oxygen needed	Products		
			CO_2	H_2O	N_2
CO_2 ..	.04		.04		
C_2H_4 .	.11	.33	.22	.22	
O_2 ...	.001	.001			
CO ..	.331	.1655	.331		
CH_4 .	.1761	.3522	.1761	.352	
H_2 ...	.303	.1515		.303	
N	.0389				.0389
Total	1.0000	.9982	.7671	.875	.0389

Assuming the gas analyses and analyses of the products of combustion as correct, we figure that on the combustion of one cubic foot of dry gas there is formed .7671 cubic foot of CO_2, and from the analysis of the dry products of combustion we find that each cubic foot of the products formed .1435 cubic foot of CO_2; therefore, there must have been formed of dry gas .7671+.1435=5.347 cubic feet of products. In the table above there was required for the combustion of one cubic foot of dry gas .9982 cubic foot of oxygen. This would be equivalent to 4.799 cubic feet or dry air, containing 3.801 cubic feet of nitrogen.

In the combustion of one cubic foot of dry gas there are formed .7671 cu. ft. of CO_2, .0389 cu. ft. of nitrogen, and the nitrogen resulting from the necessary air which we have calculated as above, equal to 3.801 cu. ft., giving a total of the theoretical products of combustion of 4.607 cu. ft.

The actual products of combustion calculated as 5.347 cu. ft.; therefore, the difference of .7400 cu. ft. must be the volume of the excess air. Calculating this as a percentage on the volume of air theoretically assuming oxygen in air as being 20.8%, we have 4.799, and we find that 15.42% excess air was used, which is equivalent to 5.53 cu. ft. of dry air per cu. ft. of dry gas, both being at the same temperature and pressure. The results of this deduction have been used in subsequent calculations.

(*c*) The Sensible Heat in the Dry Gas.

In determining the sensible heat in the dry gas, the gas analysis is again referred to, and the thermal capacity of the gas is calculated from the weights of the constituent gases and their specific heats per pound.

In the same way the thermal capacity of the products of combustion is obtained. See following table.

Gas	Volume in cu. ft.	Weight per cu. ft. in lbs.	Total weight in lbs.	Specific heat per lb.	Themal capacity B. T. U.
CO_2	.04	.11637	.004658	.216	.00100
C_2H_4	.11	.0741	.00815	.404	.00329
O_2	.001	.08463	.00085	.217	.00023
CO	.331	.07407	.02450	.245	.00600
CH_4	.1761	.04234	.00746	.593	.00442
H_2	.303	.00530	.00160	3.409	.00546
N_2	.0389	.07429	.00289	.244	.00073
					.02113
Air	5.53	.0766	.4235	.2376	.1006
		Gas and Air @ 60° F.			.12173
		Gas and Air @ 70° F.			.1194
Products of combustion					
CO_2	.1435	.11637	.0167	.216	.00361
O_2	.0205	.08463	.0017	.217	.00037
N_2	.8360	.07429	.0620	.243	.0151
		One cubic foot at 60° F.			.01980
		One cubic foot at 70° F. =			.01872

5.347 cu. ft. = .01872 x 5.347 = .1002 Thermal Capacity B. T. U.

From this thermal capacity it is very easy to calculate the sensible heat admitted and discharged by simply observing the room temperature and the exhaust product temperature in the tests 1-24. These are shown in the following table, giving actual B. T. U. absorbed and discharged by the calorimeter, due to the sensible heat in the air, gas and products of combustion.

This table was constructed by taking the room temperature, the thermal capacity of the gas and air as indicating the sensible heat admitted to the calorimeter above 0° F., and taking the exhaust temperature and thermal capacity of the products

of combustion, giving total sensible heat discharged above 0° F. The difference in these two (2) readings indicates the sensible heat absorbed or given up by the calorimeter, and is represented by Curve B, in Plate XV.

It is apparent that the difference in specific heat of the incoming and outgoing gases, and the change in volume, have only a slight influence on the heating value. Since the products of combustion of a gas containing hydrogen are always going to be less in volume than incoming gases, a small gain is always found when the inlet water is approximately at the same temperature as the room. In commercial work this error is negligible.

Tests	Room temperature	Exhaust temperature products of combustion	Sensible heat amount gas admitted	Sensible heat products of combustion discharged	Actual
1—4	69.0	45.6	8.245	4.572	+3.673
5—8	68.5	54.2	8.180	5.435	+2.745
9—12	68.5	63.2	8.180	6.340	+1.840
13—16	69.5	72.4	8.305	7.263	+1.042
17—20	70.8	81.5	8.460	8.170	+ .290
21—24	70.4	88.6	8.410	8.885	— .475

3. The Gain or Loss of Latent Heat of the Vapors in the Gases.

The combustible gas as it enters the calorimeter is usually saturated with water vapor and in these tests precaution was taken to saturate it. The air supply may be saturated to various degrees of saturation, depending on the weather conditions. Tests of the products of combustion leaving the calorimeter in all cases was only a few degrees higher than the inlet water. Tests of Dr. Immenkötter and Professor Junkers also showed that the products are saturated at the temperature of the inlet water. Now if the products of combustion are cooled far below room temperature the vapor content at the low temperature may be much less than the vapor content of the gases entering the calorimeter. Should

Effect of Latent Heat of Aqueous Vapor.

Tests No.	1-4	5-8	9-12	13-16	17-20	21-24
Barometer	28.79	28.77	28.73	28.70	28.66	28.63
Temperature of gas	69.4	68.35	67.8	67.7	68.1	68.15
Volume of dry gas	.976	.976	.976	.976	.976	.976
Volume of aqueous vapor	.024	.024	.024	.024	.024	.024
Required dry air	5.406	5.406	5.406	5.406	5.406	5.406
Temperature and humidity of air	69° @ 62%	68.5° @ 62%	68.5° @ 62%	69.5° @ 75%	70.8° @ 88%	70.4° @ 100%
Required dry air at air temperature	5.405	5.405	5.405	5.407	5.408	5.408
Required saturated air at air temperature	5.49	5.49	5.49	5.15	5.33	5.52
Volume aqueous vapor air temperature	.085	.085	.085	.108	.125	.144
Total volume aqueous vapor at air temperature	.109	.109	.109	.132	.149	.168
Weight aqueous vapor taken in pounds	.00481	.00481	.00481	.00591	.00664	.00748
Calculated volume dry products, gas temperature	5.2187	5.2187	5.2187	5.2187	5.2187	5.2187
Exhaust temperature	45.6	54.2	63.2	72.4	81.5	88.6

EFFECT OF LATENT HEAT OF AQUEOUS VAPOR.—(*Continued.*)

Tests No.	1-4	5-8	9-12	13-16	17-20	21-24
Calculated volume dry products at exhaust temperature	4.980	5.073	5.173	5.263	5.354	5.422
Calculated volume saturated products at exhaust temperature	5.035	5.147	5.286	5.414	5.561	5.706
Calculated volume aqueous vapor at exhaust temperature	.055	.074	.113	.151	.207	.284
Volume aqueous vapor 60°—30″	.0543	.07185	.1076	.1412	.1898	.257
Weight aqueous products	.00258	.00342	.00512	.00672	.00936	.01223
Total heat above 32° aqueous vapor:						
Taken in	5.3054	5.3054	5.3054	6.5187	7.3279	8.2504
Given out	+2.8277	3.7475	5.6371	7.4189	10.3615	13.5631
Gain or loss at air temperature	+2.4777	+1.5579	—.3317	—.9002	—3.0336	—5.3127
Gain or loss at 60°—30″	+2.675	+1.682	—.352	—.956	—3.225	—5.655
Corrected for one cubic foot dry gas	+2.74	+1.74	—.36	—.98	—3.31	—5.79

the products leave at a temperature higher than the room temperature, and be saturated, a greater amount of vapor is carried away than is brought in, and thus the latent heat of condensation is lost from the calorimeter.

The combustible gas enters the calorimeter at 70° F., and saturated 1 cu. ft. dry gas is equivalent to 1.024 cu. ft. gas saturated at 70° F., and hence the vapor brought in per cu. ft. of dry gas at 70° F. = 0.024 cu. ft.

Tests 1-24 are taken with the data supplied on Table 13, Series X, made on the Junkers calorimeter No. 872. The temperature is taken directly as given, as the temperature of the gas. The volume of dry gases per cu. ft. for these various barometric pressures and temperatures are calculated and show practically a uniform volume of .976 for each set of temperatures. The aqueous vapor therefore carried in per cu. ft. is .024 cu. ft.

Calculating from the analysis of the sample of gas given in the report the dry air required for combustion in each case is 5.406 cu. ft. This air was admitted in each case at different temperatures and different percentages of humidity, the required dry air in these conditions varies from 5.405 in tests 1-4 to 5.408 in tests 21-24, and required saturated air for these temperatures was 5.490 in tests 1-4 up to 5.552 cu. ft. in tests 21-24. The volume of aqueous vapor included then in the air would be .085 in the first test to .144 in the last test. This volume of aqueous vapor in the air + the volume of aqueous vapor in the gas, which was in all cases .024 made a total volume of aqueous vapor of .109 to .168 cu. ft. or expressed in pounds from .00481 to .00748 lb.

The above figures determine the weight of aqueous vapor carried in by the gas and air under actual conditions as shown by the various temperatures and pressures for each set of tests.

To determine the weight of aqueous vapor discharged in the products of combustion, we first calculate the volume of dry products from the analysis of the gas submitted. This gives a volume in all tests of 5.2187. The exhaust temperatures in each instance are taken as the actual temperatures and run from 45.6 to 88.6° F. Therefore the volume of the dry products must be expressed at these temperatures and run from 4.98 to 5.422 cu. ft.

The calculated volume of these products saturated at the same temperature above run from 5.035 to 5.706 cu. ft. The volume of aqueous vapor in the products at this temperature would then run from .055 in tests 1-4 up to .284 in tests 21-24.

Comparing the quantity of the products with the aqueous vapor in the air and gas admitted it is necessary to reduce everything to a standard volume and pressure. Therefore this aqueous vapor corrected to 60° and 30″ would be .0543 up to .2570, and the weight of this aqueous vapor would be .00258 in tests 1-4 up to .01223 lb. in tests 21-24.

From the above tables we have the total weight of aqueous vapor taken in, and the total weight of aqueous vapor discharged, hence it is necessary to determine the total heat carried in by the vapor and the total heat carried out by the vapor.

Calculating this total heat as the heat both sensible and latent above 32° F. we have total heat introduced to the calorimeter running as follows:—tests 1-4 give 5.3054 B. T. U. while tests 21-24 give 8.2504 B. T. U. In the same way the total heat carried out in aqueous vapor run in tests 1-4=2.8277 B. T. U. up to 13.5631 B. T. U. in tests 21-24.

This gives the total heat absorbed or lost by the calorimeter from the air and gas going in and the products going out under the actual conditions of temperature and pressure, and must be corrected for standard temperatures and pressures 60° and 30″ for a cu. ft. of dry gas .976 to agree with the previous investigation, which gave the following result:—

Tests	B. T. U.
1—4	+2.74
5—8	+1.74
9—12	—0.36
13—16	—0.98
17—20	—3.31
21—24	—5.79

The results of these computations are plotted as curve "C" in Plate XV. It is apparent that at the higher temperatures at which the products leave the calorimeter the loss in heat energy due to the latent heat of condensation increases very rapidly and the actual amount is large. It is necessary therefore to regulate the damper at the exit for the products of the combustion that they leave at a temperature approximately the inlet water.

Now if the curves A, B, and C, of Plate XV be combined into one curve the total losses and gains will be given, and such a curve is shown at "D" in Plate XV. The curve "D" when applied to the results shown in curve A in Plate XIV at the corresponding temperatures should give a straight line. There is a slight deviation from this condition due to experimental errors, but if the average of all these points is taken it gives a heating value of 600 B. T. U.

A horizontal line drawn through the ordinate of 600 B. T. U. cuts the curve A of Plate XIV at a point corresponding to a temperature of the inlet water of 72° F. and which is also the point of inflection of the curve. Thus it is plain that if the water supplied to the calorimeter be at room temperature and the products of combustion leave at room temperature there is a thermal balance. The interpretation of the curve having a point of inflection is that at the point of inflection the function changes from a gain to a loss, and it is apparent that the true heating value of the gas from Plate XIV is 600 B. T. U.

It may happen that the water supply available is not at room temperature, and thus an error would be made in deter-

mining the heating value. It would be convenient if a simple correction could be applied, of if the equation of the curve A on Plate XIV could be obtained. This curve has the form of a cubical parabola whose general equation is $-y = \frac{x^{\frac{3}{2}}}{a}$ where (y) = the ordinate, (x) the abscissa, and (a) the parameter. By a proper choice of a value for (a) the curve can be made to assume a variety of shapes. If the origin of the curve be at the point where the ordinate for B. T. U. rises from the point of the temperature of the inlet water corresponding to the room temperature, and if X=F° difference between the room temperature and inlet water, then (y) would give the B. T. U. to be added to or subtracted from the value found. For the curve A, Plate XIV which represents fairly average conditions the value of $(a) = 17.75$.

Suppose that a test for heating value is made with the room at 70° F., the inlet water at 60° F. Then $x = -10°$, $a^2 = 315$, and $+y = \frac{+1000}{315} = +3.16$ B. T. U. which must be subtracted. If the inlet water were at 80° F., then $x = +10°$ and $-y = \frac{1000}{315} = 3.16$ B. T. U., which means that 3.16 B. T. U. must be added to the value found.

The equation $-y = \frac{x^3}{315}$ fits the curve A, Plate XIV exactly above the room temperature, but does not fit well at more than about 12° F. below room temperature, and thus there is a limitation. A correction factor at best is undesirable, and it would be preferable if the air, gas, products of combustion and water used in the test were all at the same temperature.

The above equation holds, of course, only for a room temperature of 70° F. If the room temperature is much lower the curve will be straighter than at 70° F. and should the room temperature be much higher the curve will have about the same shape but will bend down faster at temperatures above the

room temperature. In a general way the curve will change its direction in approximately the same degree as vapor tension curves do.

The Effect of Humidity on Heating Values.

Assuming the air temperature of 70° F. and the barometer of 28.7 inches which were the mean during tests, we find one cu. ft. of saturated gas at 70°—28.7″ would be equivalent to .976 cu. ft. of dry gas, and it would therefore carry .024 cu. ft. of water vapor. This .976 cu. ft. dry gas would require at its temperature 5.406 cu. ft. dry air, which would be equivalent to 5.406 cu. ft. at 0% relative humidity to 5.547 at 100% humidity. The difference between these two would be the cu. ft. of water vapor carried by the air required for combustion. It would be equivalent to 0 cu. ft. at 0% relative humidity to .141 cu. ft. at 100% humidity or saturation, measured at 70° and at 28.7 barometer. The sum then of the vapor carried by the gas plus the vapor carried by the air would be .024 cu. ft. at 0% to .165 cu. ft. at 100%. Reducing this to 60° and 30″ gives .02252 to .1548 cu. ft., or expressed in pounds would be .001072 for 0% to .007375 at 100%.

The actual volume of dry gas burned has been .976 cu. ft. From former calculations 5.219 cu. ft. of dry products of combustion are obtained from 1 cu. ft. of saturated gas. This is equivalent to 5.358 cu. ft. saturated. The difference or .139 is the volume of water vapor carried out by the products of combustion measured at 70° and 28.7 barometer. Reducing this to 60° and 30″ gives us .1305 cu. ft. This would weigh .00621 pound, which is the weight of water vapor carried out of the calorimeter by the products of combustion. Subtracting from this quantity which is constant, as the products always leave saturated, from the pounds of water vapor carried into the calorimeter by the air and gas under the different conditions assumed, we have the following quantities of water vapor gained or lost by the calorimeter; that is —.00514 lb. was lost at 0% and +.00117 lb. was gained at

100%, multiplying this mass of water vapor by its heat of vaporization at 70° we have the actual heat in B. T. U. which was gained or lost by the calorimeter by the combustion of one cu. ft. saturated gas at 70° and 28.7 barometer.

CORRECTING TO 60° AND 30".

Humidity	Corrected
0%	—5.90
25%	—4.155
50%	—2.130
75%	— .303
100%	+ .858

The curve as shown by actual reading is given in Plate XVI. The calculated curve is shown in Plate XVIa.

TESTS OF OTHER CALORIMETERS.

Since the above tests were concluded it was decided by the Committee to investigate still further the several calorimeters that had appeared on the American market, and were being used in commercial practice. The instruments brought most forcibly to our attention were the Graefe calorimeter, designed by Dr. Graefe of Germany, and the 1909 model of the Sargent Steam Meter Co., Chicago. This second instrument being the result of the changes made to the improved type calorimeter, presented in 1908, and was apparently designed to meet the recommendations made by the American Gas Institute, Committee on Calorimetry in 1908.

It was understood that there were several other calorimeters in process of development, among which were the Doherty, the Parr and the Lucke. However, none of these instruments were available to the Committee. No attempt was made to gather various calorimeters for testing purposes, as the investigation this year was more to determine the effect on heat-

One Cubic Foot of Saturated Gas at 70°F.

Relative humidity	Moist air for 1 c. f. gas cu. ft.	Aqueous vapor in air @ 70° 24.7″ cu. ft.	Total moisture gas and air 60°—30″ cu. ft.	Aqueous vapor: Carried in lbs.	Aqueous vapor: Carried out lbs.	Aqueous vapor: Retained or given up lbs.	Heat in aqueous vapor 70° 29.7″ B. T. U.	Heat in aqueous vapor 60°—30″ B. T. U.
0%	5.406	.000	.024	.001072	.00621	.00514	—5.474	—5.90
25%	5.441	.035	.059	.002637	.00621	.00357	—3.805	—4.155
50%	5.480	.074	.098	.00438	.00621	.00438	—1.950	—2.130
75%	5.515	.109	.133	.005947	.00621	.00595	— .277	— .303
100%	5.547	.141	.165	.007375	.00621	.00738	+ .786	+ .858

1 Contains cu. ft. of dry gas	2 Carries cu. ft. of aqueous vapor	3 Requires cu. ft. of dry air for combustion	4 Yields cu. ft. of dry products of combustion	5 Equivalent volume saturated products of combustion	6 Carries aqueous vapor in products of combustion	7 Equivalent aqueous vapor at 60° — 30″
.976	.024	5.406	5.219	5.358	.139	.1305

ing value of the many varying conditions likely to arise in commercial operation.

The Committee, nevertheless, would have looked into the merits of any instrument if it had found them in use in any of our operating companies, as it did with the Graefe calorimeter, which was called to its attention during the last annual meeting. This instrument was supplied to fill a long felt want of a cheap calorimeter to give quick and approximate readings; in this it failed, while being cheap and supposedly quick in operation it gave results that may not even be considered approximate, and for commercial purposes its use is to be avoided in all instances, as will be seen from the data of results obtained in a test submitted below.

The Sargent Calorimeters.

The Sargent calorimeters which were obtained for these tests had no serial numbers so were designated as No. 1, belonging to the Chemical Engineering Dept. of the University of Wisconsin, and No. 2, belonging to the United Gas Improvement Co. of Philadelphia. These instruments were materially different from the preceding models investigated last year, the entire calorimeter being made of metal with the outside casing nickeled and polished.

Weir overflows are located at both the inlet and outlet water supply, the weirs being detachable from the body of the calorimeter. Both thermometers are at the same height, and from the point where the inlet thermometer is inserted, a pipe leads the water to the bottom of the calorimeter. A cock with a graduated dial serves to regulate the water entering the calorimeter.

The water capacity of the calorimeter has been reduced somewhat over previous Sargent models, being now about 3.6 lbs., which is about equal to that of the Junkers. The burner has also been improved by the addition of a regulating cock.

Instead of the old style of dry pressure regulator for the gas supply, a wet type of pressure regulator has been substituted. The meter has also been improved by adding a plug at the bottom of the meter for draining purposes. A funnel is placed on the gauge glass for the addition of water to adjust the level in the meter and a pointer on the outside of the gauge glass has been substituted for the screw inside.

Graefe Calorimeters.

This calorimeter consists essentially of a metal cylinder holding a known quantity of water, and a hole in the center for the admission of the gas burner. The metal cylinder has a core in the center forming an annular space between it and the outside shell that holds the water, one liter being the normal content. The gas burner, of a luminous flame type one inch high, is placed inside the core or center hole which is open both top and bottom to the air. A wire rod with screens is inserted inside the core for the purpose of baffling the heated current of air and product of combustion, and allowing a better absorption of the heat by the inside walls of the calorimeter and the contained water.

A thermometer is inserted through a cork placed in the top of the annular space over the water, this thermometer is immersed in water which is kept in motion or is agitated occasionally by a stirring rod also inserted through the top cork.

No gas meter is provided with this calorimeter, but the gas is measured by being displaced by water from a graduated bottle holding something over 6 liters. This bottle acts both as a storage vessel and meter, and is provided with a device inserted in the mouth of the bottle, allowing for the escapement of gas and admission of the water, and also to remove the water and aspirate a sample of gas when it is refilled.

Methods of Testing.

The methods of testing these calorimeters were exactly similar to those adopted previously, and all thermometers

and meters were carefully calibrated and corrections made for any inaccuracies. The comparative tests were made simultaneously, the gas supply, water supply and exhaust products from the calorimeter being maintained at approximately the temperature of the room.

Test of Sargent Calorimeters.

The Sargent calorimeters were tested first for the best position of the exhaust damper which determined the proportion of the air necessary for complete combustion. The second test was for the most efficient rate of combustion and the third test for comparative efficiency.

Best Position of Damper.

The Sargent calorimeters have at the exhaust vent a sliding damper upon which is scratched a scale having divisions about one-tenth of an inch apart. With this scale the damper can always be readily set to the same position which has been determined to give the highest reading of the heating value. In these tests the position of the damper has been designated as follows:—At the division 0 the damper is wide open and at the 20th division the damper is completely closed. A series of tests were made with the damper respectively at division 0, 10, 15, and 17.

The result of series A H show the relative indications of the heating value as given by the calorimeter with the damper set at different divisions. A subsequent series of tests of the effect of the position of the damper was made and the results of these tests are given in series A H. The results are uniformly low when the damper is wide open and the heating value increases as the damper is closed to the division 15. With the damper closed beyond this division there is not sufficient draught through the calorimeter, incomplete combustion results and the heating value drops very abruptly to a low figure.

The results of the series A F have not been plotted in the form of a curve because there were only two points deter-

mined, viz., with the damper wide open and the damper set at division 15. The results of series A H, as shown in the tabulated data, prove that low results are obtained with the damper wide open and the best results with the damper set at about division 15.

Most Efficient Rate of Combustion.

In the operation of every calorimeter there is a rate of combustion at which the calorimeter will give the highest heating value, everything else being equal. So in these tests, before any comparative tests were attempted, the rate of combustion at which the Sargent calorimeters would give the highest indication of the heating value of the gas, was determined. This series of tests has been called A J and the results show that both the Sargent calorimeters give the maximum heating value with a rate of combustion equal to 6 cubic feet of gas per hour. There seems to be little difference, however, between the indications at the rates of 6 and 7 cubic feet per hour. See Plates XVII and XVIII.

The results of these tests are shown in the tabulated data and in the accompanying curves, from which the most efficient rate of combustion can be readily deduced.

Comparative Efficiency Tests.

In determining the efficiency of these Sargent calorimeters it was decided to make comparative tests with the calorimeter whose efficiency had been determined by means of the electrical heater as described in the 1908 Report. So for this purpose the No. 872 Junkers was used whose ultimate efficiency had been proven to be slightly over 99.5%.

All these instruments were operated at the same time and under exactly the same conditions as they were such as would produce the most efficient and uniform results.

The average of nine tests were taken in each case as one reading was spoiled in operating each calorimeter. The total average heating value of the Sargent No. 1 was 602.5 B. T. U. The Sargent No. 2 was 602.9 B. T. U., while the Junkers

No. 872 showed an average of 602.1 B. T. U. which was afterward corrected to 602.7 B. T. U., due to a recalibration of the Junkers meter which was proven against the ½ cu. ft. bottle and found to be .1% fast.

This comparison gave evidence that both types of instruments had been so designed, that with careful handling under certain prescribed directions the results obtained were identical, and must certainly be near to the total available heat of the gas.

The Sargent calorimeters were open to some criticism because of certain mechanical features and careless workmanship. The body of the calorimeter was rather heavy weighing about 23½ lbs., this excessive weight causing a sluggishness in the indications of the outlet thermometer. Several of the water channels throughout the instrument were choked with pieces of solder, some of which were shaken out while others it was impossible to remove. One criticism of all the calorimeters and particularly so of the Sargent was that the entire body of the instrument is soldered together making it impossible to clean the inside of the instrument. Long usage has shown that it is desirable to be able to dismantle the calorimeter so that the various water channels may be cleaned. The post supporting the burner of the Sargent calorimeter was not made carefully enough to be sure of locating the burner in the center of the combustion chamber. Several low readings were obtained due to the fact that the flame impinged on the side of the combustion chamber and was cooled so as to produce incomplete combustion.

Tests on the Graefe Calorimeter.

The Graefe calorimeter as stated before has no meter but the gas is stored and measured in a bottle holding approximately 6 liters of gas and upon the side of the bottle a scale from 0-5 liters is etched. The graduations are to single liters. This bottle was calibrated against a wet test meter No. 437 made by the American Meter Company. The results of this calibration showed that it was impossible to read the

large meniscus formed on the surface of the bottle with any accuracy, the results being:—

0—1	liter	bottle	=	.034	cu. ft.
1 2	"	"	=	.033	cu. ft.
2 3	"	"	=	.033	cu. ft.
3 4	"	"	=	.035	cu. ft.
4 5	"	"	=	.0325	cu. ft.

a true liter being .0353 + cu. ft., or an error from 3 to 7%.

The burner furnished with this calorimeter gave a luminous flame and great care was necessary in placing the lighted burner in the calorimeter so that the flame did not touch the wire support for the gauze inside the combustion chamber. It was also observed that the flame would sometimes go out and immediately relight, and at the instant that the flame relighted, it shot upward about an inch beyond its normal height and at this point the flame would touch the gauze inside the combustion chamber and deposit a considerable amount of soot.

After making several tests this luminous flame was discarded in favor of a non-luminous bunsen.

The thermometer furnished with the Graefe instrument was an ordinary chemical thermometer having a range from 0—95° and graduated to single degrees. Such a thermometer as this, could at best give only very approximate results and it was extremely difficult to observe any slight changes in the temperature of the water in the calorimeter. Several tests were made with this thermometer and then a Fahrenheit thermometer graduated from 0.1° was substituted and further tests made.

As stated in the prospectus and directions furnished with the instrument, the Graefe calorimeter must be standardized against some other standard calorimeter which will give the true heating value of the gas. For these tests, labeled series AN, the heating value of the gas was first determined by the Junkers calorimeter No. 872.

In this series readings were obtained of the total heating value of the gas, as well as the total heating value, less the latent heat of the condensed water formed in the products of combustion. This was deemed necessary, as the Graefe calorimeter does not in any case account for this latent heat as the products of combustion pass off at such a temperature that none of the water vapors thus formed are condensed.

It is necessary to make tests on the Graefe calorimeter in a room that is free from draughts and the operator must be careful not to move suddenly because the small flame, which is only one inch high, is easily deflected from its natural course. It is apparent, also, that the water which is used in the calorimeter should be at room temperature.

The first tests made on the Graefe calorimeter were made with the burner furnished with the instrument and 5 liters of gas burned per test. After about 2½ liters of gas had been burned the flame began to flicker, and would almost go out, then flare up high, burn steadily for a little while, and repeat the performance more frequently as the amount of gas approached 5 liters.

This flickering of the flame is due to the diminishing pressure with which the gas is forced through the burner. The water which displaces the gas from a bottle is delivered from a small cup above the bottle at a constant level, consequently, as the gas is forced out of the bottle the head of pressure is becoming less and finally there is not sufficient head to force the same quantity of gas through at 4½ liters as there was at the beginning of the test when the bottle was full of gas.

Because of these irregularities with the operation of the Graefe calorimeter when 5 liters of gas were burned per test, 2 liters of gas were burned for some of the subsequent tests. With this quantity of gas there was no difficulty in maintaining a steady flame, but upon burning the second two liters, say from the division 3 liters to division 5 liters, the cock regulat-

ing the water admitted for displacement of gas had to be regulated to give a greater quantity of water for displacement.

As shown in the curve of the series AN, tests Nos. 3, 4 and 5 are fairly close together. These tests were made with the calorimeter as it was purchased. Tests Nos. 6 and 11 were made on this calorimeter using a non-luminous bunsen burner with a flame 3 cm. high and a thermometer graduated to 0.1° F. It is apparent from these later tests that there is a considerable variation in the indications of this instrument. There is a variation of 20 B. T. U. between the low and the high reading in tests Nos. 6-11.

Some tests were then made, using the non-luminous bunsen and the thermometer graduated to 0.1° F., but burning 4 liters per test. The results for the tests 12 and 13 show that the indications of heating value with this arrangement is again lower, just as the indications with the original calorimeter outfit were low when 5 liters of gas were burned per test.

The directions furnished with the calorimeter state that the B. T. U. per cu. ft. equals $\frac{M \times 142.5}{N}$. This supposes that the calorimeter is 79.3% efficient, in the above equation. M equals the rise of temperature in degrees Centigrade and N signifies the liters of gas burned. Now, 1 liter of water = 2.204 lbs., 1 liter of gas = 0.035 cu. ft. Hence, the B. T. U. per cu. ft. $= \frac{M \times 1.8 \times 2.204}{N \times 0.035 \times (X)}$, where X would equal the percentage that the heating value as given by the Graefe calorimeter is of the heating value as given by some standard calorimeter. The constant, 142.5, is derived from the last equation, supposing that X is equal to 0.973, which is the ratio of the heating value of the Graefe calorimeter and the heating value given by a standard calorimeter.

From tests shown in series AN the average heating value of the gas tested was 598.2, the value deducting the latent heat of the products of combustion was 558.5.

A reference to the tabulated data of the tests on the Graefe calorimeter series AN shows the exhaust temperature to be over 100° F. and in some cases reading as high as 150° F. This high temperature with the naturally large excess of air admitted will prevent the condensation of any water vapors formed during combustion and the latent heat of this water will never be taken into account by the calorimeter.

The efficiency or correction factor of the Graefe calorimeter as shown by the circular of instructions is .793 which if applied to the heating value of the gas as shown in series AN tests 1 and 2 is

376.4÷.793=474.6 B. T. U.

if applied to tests 3 to 11 inclusive is

411.7÷.793=519.2

and in tests 12 and 13

389.7÷.793=491.4

If the total heating value of this sample of gas as read by the Junkers calorimeter of 598.2 is considered as a standard the results indicated by the Graefe instrument are only in the successive tests, from 79% to 87% of its true value and represent only from 85% and 93% of its low heating value.

Thus it is apparent that it is necessary to specify the amount of gas which has been burned for each test of the Graefe calorimeter. It appears that a small quantity of gas burned per test will give a higher indication of heating value than a larger amount of gas burned. The reason for this is easy to see, because the more gas that is burned, the hotter the water in the calorimeter will become, and consequently the greater will be the radiation from the walls of the calorimeter, and greater will be the losses from products of combustion and entrained air.

Calorimeter Cabinet.

For the purpose of facilitating the use of the calorimeter for commercial purposes it is desirable that the instrument shall be permanently installed, and always in a position to make quick and accurate readings. For this purpose your

Committee has designed a type of calorimeter cabinet, a cut of which is attached and shows its general plan and usefulness. It can be installed in any laboratory or conveniently erected in the rear of any office. It provides for a supply of water at the temperature of the room, for a supply of gas from some permanent selected source, and for a careful protection of all auxiliary instruments.

This cabinet should be made dust proof, and should always be kept closed and locked when not in use. High grade thermometers may then be used without risk of much handling or meddlesome interference.

The construction of such a cabinet should insure an operating company of having a calorimeter at all times ready for instant use.

Conclusions.

After this second year's investigation your Committee is convinced that the general instructions and precautions given in the report of 1908 are correct, and need but little modification. A few words might be said, however, in regard to the general selection of calorimeters and measuring instruments.

With reference to the meter. The specifications for the gas meter as given in 1908 are to be commended. Further experience has shown that the meter with the internal overflow has been the cause of many erratic readings in some very important investigations. We recommend that this type of meter be discarded and only that with the exterior water gauge glass be used, and that the meters be calibrated and tested at the pressures and rate of flow at which they will be used.

With reference to thermometers. We recommend that great care be used in the selection of thermometers and that the thermometers that are used in measuring the inlet and outlet water temperatures should be calibrated in every case. We would recommend for all commercial purposes the selection of

thermometers in accordance with the description previously noted in this report.

The type of calorimeter to be used was described in last year's report and the Committee has few remarks to make further on this point, except that it is preferable to have an instrument that is so made that the interior is accessible for cleaning purposes. After continual service with an impure water, there will be deposited mud or scale on the interior water channels which will tend to decrease the efficiency and general accuracy of the calorimeter.

The placing of the thermometers on the same level is recommended; as in last year it has been show that suitable calorimeters can be made with this design in view.

The Committee wishes to give all credit for the experimental work done in this investigation during the past year to Mr. O. L. Kowalke, of the Chemical Engineering Dept., of the University of Wisconsin.

This work has enabled us to extend the field of our investigation, as suggested in the 1908 report, and enables us to reaffirm last year's directions for the use of calorimeters. It clearly shows the relative effect of the several possible sources of error not covered by last year's work.

Respectfully submitted,

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C. F. Burgess.
R. C. Cornish.
O. L. Kowalke.

TABLE 12.—SERIES Z.

Junkers No. 872.

	1	2	3	4	5	6	7
Barometer	28.84	28.84	28.84	28.84	28.84	28.84	28.84
Gas temperature	68.18	68.24	67.60	68.48	68.57	68.72	69.08
Correction factor	0.9402	0.9400	0.9423	0.9394	0.9391	0.9388	0.9378
Room temperature	70.	70.	69.6	70.	70.	70.3	71.
Exhaust temperature	72.7	73.	73.	73.	73.5	73.5	74.
Gas rate, cu. ft. per hour	6.97	6.90	6.92	6.92	6.92	6.92	6.92
Gas consumed, cu. ft.	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, lbs.	10.625	7.216	5.463	4.553	3.615	3.139	2.841
Inlet temperature	70.546	70.450	70.378	70,635	70.845	70.873	71.148
Outlet temperature	80.847	85.609	90.454	94.599	100.623	105.525	109.295
Difference, F°	10.301	15.159	20.245	23.633	29.778	34.652	38.147
B. T. U.	581.8	581.9	582.1	580.8	581.0	579.3	577.7

TABLE 13.—SERIES X.

Junkers No. 872.

	1-4	5-8	9-12	13-16	17-20	21-24
Barometer	28.79	28.77	28.73	28.70	28.66	28.63
Temperature gas	69.4	68.35	67.8	67.7	68.1	68.15
Correction factor	0.9354	0.9374	0.9374	0.9366	0.9344	0.9328
Humidity, per cent.	62.	62.	62.	75.	88.	100.
Room temperature	69.	68.5	68.5	69.5	70.8	70.4
Exhaust temperature	45.6	54.2	63.2	72.4	81.5	88.6
Gas rate, cu. ft. hr.	6.78	6.77	7.05	6.9	6.91	6.92
Gas consumed, cu. ft.	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, pounds	7.499	7.428	7.251	7.306	7.295	7.255
Inlet temp., "C."	3.894	9.585	15.352	21.304	26.765	31.819
Outlet temp., "C."	12.496	18.098	23.953	29.844	35.259	40.132
Difference, F°	15.482	15.279	15.518	15.385	15.289	14.972
B. T. U.	620.2	608.2	601.2	600.2	596.8	582.1

TABLE 14.—SERIES AA.

Junkers No. 872.

	1	2	3	4
Barometer	29.06	29.04	29.04	29.00
Temperature, gas	68.4	68.2	68.0	67.82
Correction factor	0.9466	0.9469	0.9466	0.9465
Humidity	40.	49.	56.	68.
Room temperature	70.	69.5	69.	69.
Exhaust temperature	72.5	73.	72.5	72.5
Gas rate, cu. ft. hr.	6.79	6.80	6.80	6.80
Gas consumed, cu. ft.	0.2	0.2	0.2	0.2
Water heated, pounds	8.113	8.102	8.107	8.11
Inlet temp.	70.481	70.715	70.456	70.624
Outlet temp.	84.450	84.734	84.480	84.634
Difference	13.969	14.019	14.024	14.010
B. T. U.	598.5	599.5	600.3	600.5

TABLE 15.—SERIES AJ.

Sargent No. 1.

	1	2	3	4	5	6	7	8	9	10	11
Barometer	29.10	29.10	29.10	29.10	29.10	29.10	29.12	29.10	29.10	29.10	29.10
Temp. of gas ...	78.26	78.26	78.26	78.44	78.44	78.44	78.44	78.98	78.98	78.8	79.25
Cor. factor	.9218	.9218	.9218	.9215	.9215	.9215	.9222	.9200	.9200	.9224	.9192
Temp. of room ..	81.	81.	81.	81.	81.	81.	81.	82.	82.	82.	82.
Temp. exhaust .	79.	79.	79.	79.0	79.	79.	79.	79.5	79.	79.	79.
Rate of gas cu.ft.hr.	3.05	3.00	3.00	3.91	3.89	3.91	3.91	5.07	5.07	5.10	5.95
Gas consumed, cu. ft. .	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Water heated, liters ..	3.592	3.605	3.610	3.705	3.690	3.680	3.709	7.260	7.260	7.257	7.175
Inlet temp.	77.592	77.592	77.607	77.770	77.793	77.809	77.844	77.943	77.963	77.973	78.007
Outlet temp. .	92.739	92.677	92.703	92.449	92.557	92.647	92.583	93.973	92.987	93.010	93.255
Difference	15.147	15.085	15.096	14.679	14.764	14.838	14.739	15.030	15.024	15.037	15.248
B. T. U.	590.2	590.0	591.1	590.3	591.4	592.5	592.9	593.0	592.8	591.5	505.0

TABLE 15.—SERIES AJ.—(*Continued.*)

Sargent No. 1.

	12	13	14	15	16	17	18	19	20	21	22
Barometer	29.10	29.10	29.09	29.09	29.08	29.08	29.08	29.08	29.08	29.08	29.08
Temp. of gas ...	79.19	79.16	79.88	79.34	79.34	79.52	79.52	79.34	79.25	79.25	79.25
Cor. factor	.9193	.9193	.9171	.9187	.9184	.9177	.9177	.9184	.9185	.9185	.9185
Temp. of room ..	82.	82.	82.	82.	82.	82.	82.	82.	82.	82.	82.
Temp. of exhaust	79.	79.	79.	79.	79.	80.	79.	79.	79.	79.	79.
Rate of gas cu.ft.hr.	6.0	5.96	6.79	6.85	6.85	8.14	8.09	8.09	9.0	9.0	9.0
Gas consumed cu. ft. .	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, liters ..	7.155	7.148	7.098	7.083	7.090	7.049	7.049	7.045	6.808	6.825	6.810
Inlet temp.	78.014	78.014	78.074	78.074	78.094	78.075	78.021	77.994	77.883	77.873	77.844
Outlet temp. ..	93.256	93.265	93.422	93.419	93.445	93.522	93.423	93.426	93.684	93.584	93.625
Difference	15.242	15.251	15.348	15.345	15.351	14.447	15.402	15.432	15.801	15.711	15.781
B. T. U.	593.1	592.9	593.9	591.5	592.5	593.2	591.5	591.9	585.5	583.7	585.0

TABLE 16.—SERIES AJ.

Sargent No. 2.

	1	2	3	4	5	6	7	8
Barometer	29.10	29.10	29.10	29.10	29.10	29.10	29.12	29.10
Temp. of gas	78.26	78.26	78.26	78.44	78.44	78.44	78.44	78.98
Correction factor ...	.9218	.9218	.9218	.9215	.9215	.9215	.9222	.9200
Temperature of room.	81.	81.	81.	81.	81.	81.	82.	81.5
Temp. of exhaust ...	79.	79.	79.	79.	79.	79.	80.	79.5
Rate of gas, cu. ft. hr.	2.91	2.92	2.92	3.86	3.87	3.87	4.98	5.0
Gas consumed, cu. ft.	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Water heated, lbs. ..	3.658	3.641	3.666	3.645	3.655	3.655	7.345	[illegible]27
Inlet temperature ...	77.610	77.590	77.623	77.769	77.810	77.828	77.952	77.980
Outlet temperature ..	92.691	92.671	92.681	92.954	92.947	92.978	93.031	93.049
Difference	15.081	15.081	15.058	15.185	15.137	15.150	15.079	15.069
B. T. U.	598.4	595.6	598.8	600.6	600.3	600.9	600.4	600.0

TABLE 16.—SERIES AJ.—(*Continued.*)

Sargent No. 2.

	9	10	11	12	13	14	15	16
Barometer	29.10	29.10	29.10	29.10	29.10	29.09	29.09	29.08
Temp. of gas	78.98	78.80	79.25	79.16	79.16	79.88	79.34	79.34
Correction factor ...	.9200	.9224	.9192	.9193	.9193	.9171	.9187	.9184
Temperature of room.	81.5	81.5	81.5	81.7	82.	82.	82.	82.
Temp. of exhaust ...	79.5	79.5	79.5	79.7	79.5	80.7	80.	79.8
Rate of gas, cu. ft. hr.	5.0	5.0	5.86	5.78	5.80	6.66	6.74	6.66
Gas consumed, cu. ft.	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, lbs. ..	7.319	7.337	7.443	7.375	7.352	7.353	7.370	7.335
Inlet temperature ...	77.991	78.011	78.036	78.031	78.031	78.091	78.091	78.091
Outlet temperature ..	93.087	93.089	92.952	93.041	93.036	93.109	93.093	93.103
Difference	15.087	15.089	14.916	15.010	15.005	15.018	15.002	15.012
B. T. U.	600.1	600.1	603.8	601.5	600.0	602.0	601.7	599.4

TABLE 16.—SERIES AJ.—(*Continued.*)

Sargent No. 2.

	17	18	19	20	21	22	23
Barometer	29.08	29.08	29.08	29.08	29.08	29.08	29.08
Temperature of gas	79.52	79.52	79.34	79.25	79.25	79.25	79.25
Correction factor	.9177	.9177	.9184	.9185	.9185	.9185	.9185
Temperature of room	82.	81.5	81.	81.	81.	81.	80.7
Temperature of exhaust	79.8	80.	80.	80.	80.	80.	80.
Rate of gas, cu. ft. hr.	6.66	8.27	8.18	8.21	8.78	8.88	8.78
Gas consumed, cu. ft.	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, lbs.	7.361	7.416	7.419	7.427	7.128	7.130	7.128
Inlet temperature	78.091	78.091	78.031	78.000	77.911	77.880	77.840
Outlet temperature	93.131	92.970	92.922	92.858	93.356	93.301	93.271
Difference	15.040	14.879	14.891	14.858	15.445	15.421	15.431
B. T. U.	603.1	601.1	601.4	600.7	599.3	598.5	598.7

TABLE 17.—SERIES AH.

Sargent No. 1.

	1	2	3	4	5	6	7	8
Barometer	29.16	29.16	29.16	29.16	29.16	29.16	29.16	29.16
Temp. of gas	75.38	75.56	75.56	75.56	75.74	75.74	75.74	75.74
Correction factor	.9321	.9314	.9314	.9314	.9308	.9308	.9308	.9308
Temperature of room.	78.0	78.	78.	78.4	78.5	78.5	78.5	78.5
Temp. of exhaust ...	77.	77.	77.	77.	77.	77.	77.	77.
Rate of gas, cu. ft. hr.	5.10	5.10	5.12	5.12	5.10	5.10	5.12	5.14
Gas consumed, cu. ft.	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, lbs. ..	7.511	7.502	7.498	7.500	7.502	7.494	7.481	7.480
Inlet temperature ...	75.766	75.796	75.859	75.885	75.921	75.96	76.010	76.054
Outlet temperature ..	90.733	90.770	90.832	90.859	90.942	90.911	89.822	89.865
Difference	14.967	14.984	14.973	14.974	15.021	14.951	13.812	13.811
B. T. U.	603.0	603.4	602.6	602.9	605.3	601.9	555.0	554.9
Damper at division ...	0.00	0.00	10.00	10.00	15.00	15.00	17.00	17.00

TABLE 18.—SERIES AH.

Sargent No. 2.

	1	2	3	4	5	6	7	8
Barometer	29.16	29.16	29.16	29.16	29.16	29.16	29.16	29.16
Temp. of gas	75.38	75.56	75.56	75.56	75.74	75.74	75.74	75.74
Correction factor	.9321	.9314	.9314	.9314	.9308	.9308	.9308	.9308
Temperature of room.	78.	78.	78.	78.	78.2	78.4	78.	78.
Temp. of exhaust....	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.3
Rate of gas, cu. ft. hr.	5.0	5.02	5.0	5.0	4.98	4.98	5.0	5.0
Gas consumed, cu. ft.	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, lbs. ..	7.562	7.564	7.583	7.582	7.591	7.593	7.580	7.581
Inlet temperature ...	77.760	75.80	75.841	75.881	75.917	75.950	76.000	76.036
Outlet temperature ..	90.793	90.82	90.877	90.858	90.958	90.932	88.365	88.357
Difference	15.033	15.02	15.036	14.977	15.041	14.982	12.365	12.321
B. T. U.	609.8	609.8	612.0	609.5	617.6	611.0	503.4	496.3
Damper at division ..	0.00	0.00	10.00	10.00	15.00	15.00	17.00	17.00

TABLE 19.—SERIES AM.

Junkers No. 872.

	1	2	3	4	5	6	7	8	9
Barometer .	28.96	28.96	28.96	28.96	28.96	28.96	28.96	28.96	28.96
Temp. of gas	77.36	77.36	77.54	77.54	77.90	77.90	77.90	78.08	78.26
Cor. factor.	.9198	.9198	.9195	.9195	.9185	.9185	.9185	.9179	.9172
Temp. of room	79.5	79.5	79.5	79.5	79.5	80.5	80.5	80.5	80.5
Temp. of exhaust ..	82.	82.	82.	82.	82.	82.	82.	82.	82.
Rate of gas, cu. ft. hr..	6.92	6.92	6.92	6.92	6.92	6.91	6.00	6.92	6.92
Gas consumed, cu. ft. ...	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, pounds ..	7.383	7.368	7.393	7.399	7.394	7.396	7.397	7.400	7.410
Inlet temp...	79.898	79.977	79.998	80.028	80.058	80.079	80.079	80.129	80.179
Outlet temp.	94.927	95.011	94.985	95.008	95.036	95.021	95.015	95.044	95.078
Difference..	15.029	15.034	14.987	14.980	14.978	14.942	14.936	14.915	14.899
B. T. U. ...	603.4	602.1	602.4	602.7	602.8	601.5	601.4	601.2	601.8

Average for nine (9) tests = 602.1 B. T. U.

Correcting for .1% meter error = 602.7 B. T. U.

TABLE 20.—SERIES AM.

Sargent No. 1.

	1	2	3	4	5	6	7	8	9
Barometer .	28.96	28.96	28.96	28.96	28.96	28.96	28.96	28.96	28.96
Temp. of gas	77.36	77.36	77.54	77.54	77.90	77.90	77.90	78.08	78.26
Cor. factor.	.9198	.9198	.9195	.9195	.9185	.9185	.9185	.9179	.9198
Temp. of room	79.5	79.5	80.	80.	80.5	80.5	80.5	80.5	81.
Temp. of exhaust ..	81.	81.	81.	81.	81.	81.	81.	81.	81.
Rate of gas, cu. ft. hr..	5.92	5.94	5.90	5.90	5.92	5.94	5.94	5.94	5.94
Gas consumed, cu. ft. ...	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, pounds ..	7.288	7.299	7.295	7.308	7.302	7.291	7.287	7.274	7.283
Inlet temp...	79.980	80.030	80.070	80.100	80.120	80.130	80.177	80.211	80.240
Outlet temp.	95.167	95.237	95.264	95.284	95.318	95.323	95.346	95.390	95.448
Difference ..	15.187	15.207	15.194	15.184	15.198	15.193	15.169	15.179	15.208
B. T. U. ...	601.7	603.3	602.7	603.4	604.1	602.7	601.7	601.4	602.0

Average for nine (9) tests = 602.5 B. T. U.

TABLE 21.—SERIES AM.

Sargent No. 2.

	1	2	3	4	5	6	7	8	9
Barometer .	28.96	28.96	28.96	28.96	28.96	28.96	28.96	28.96	28.96
Temp. of gas	77.36	77.36	77.54	77.54	77.90	77.90	78.08	78.08	78.26
Cor. factor.	.9198	.9198	.9195	.9195	.9185	.9185	.9179	.9179	.9172
Temp. of room	79.5	79.5	79.5	79.5	80.5	80.5	80.5	80.5	80.5
Temp. of exhaust ..	81.	81.	81.	81.	81.	81.	81.	81.	81.
Rate of gas, cu. ft. hr..	5.85	.5.85	5.80	5.80	5.80	5.77	5.77	5.77	5.77
Gas consumed, cu. ft. ...	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water heated, pounds ..	7.397	7.415	7.457	7.457	7.496	7.531	7.531	7.543	7.564
Inlet temp...	77.990	80.020	80.040	80.085	80.117	80.120	80.170	80.22	80.220
Outlet temp.	94.970	94.972	94.928	94.948	94.888	94.841	94.832	94.895	94.887
Difference ..	14.980	14.952	14.888	14.863	14.771	14.721	14.662	14.675	14.667
B. T. U. ...	602.3	602.7	603.7	602.7	602.1	603.5	601.4	602.9	604.7

Average for nine (9) tests, 602.9.

TABLE 22.—SERIES AN.

Junkers No. 872.

	1	2	3	4	5
Barometer	29.02	29.02	29.02	29.02	29.02
Temperature of gas	78.26	78.44	78.62	78.80	78.98
Correction factor	.9192	.9189	.9183	.9180	.9173
Room temperature	80.	80.	81.	81.5	81.5
Exhaust temperature	81.	81.	81.	81.	81.
Rate of gas consumed	6.92	6.92	6.92	6.94	6.92
Cu. ft. of gas used	0.2	0.2	0.2	0.2	0.2
Weight water heated	7.335	7.330	7.347	7.338	7.344
Temperature water inlet	78.567	78.646	78.670	78.715	78.772
Temperature water outlet	93.543	93.620	93.644	93.681	93.749
Rise in temperature	14.976	14.974	14.974	14.966	14.977
B. T. U.	597.5	597.2	598.9	598.1	599.5

Average B. T. U., 598.2.

Condensed water per cu. ft., 16.4 c.c.

Average heating value, less latent heat of products of combustion condensed, 558.5

TABLE 23.—SERIES AN.

Graefe Calorimeter.

	1	2	3	4	5	6
Barometer	29.02	29.02	29.02	29.02	29.00	29.00
Temperature of gas	78.54	78.0	79.5	79.0	80.4	80.0
Room temperature, °F. ..	81.5	81.5	81.0	81.0	81.	81.
Exhaust temperature, °F.	137.0	159.5	....	120	128	116
Height flame, cm.	3	3	3	3	3	3
Gas consumed, liters	5	5	2	2	2	2
Water heated	1000	1000	1000	1000	1000	1000
Initial temperature	26.70°C.	24.80°C.	25.0°C.	25.00°C.	25.0°C.	25.01°C.
Final temperature	43.00°C.	42.00°C.	32.3°C.	32.4 °C.	32.3°C.	32.5 °C.
Rise of temperature	16.30°C.	17.20°C.	7.3°C.	7.4 °C.	7.3°C.	7.49 °C.
B. T. U.	366.4	386.5	410.1	410.7	410.3	421.0

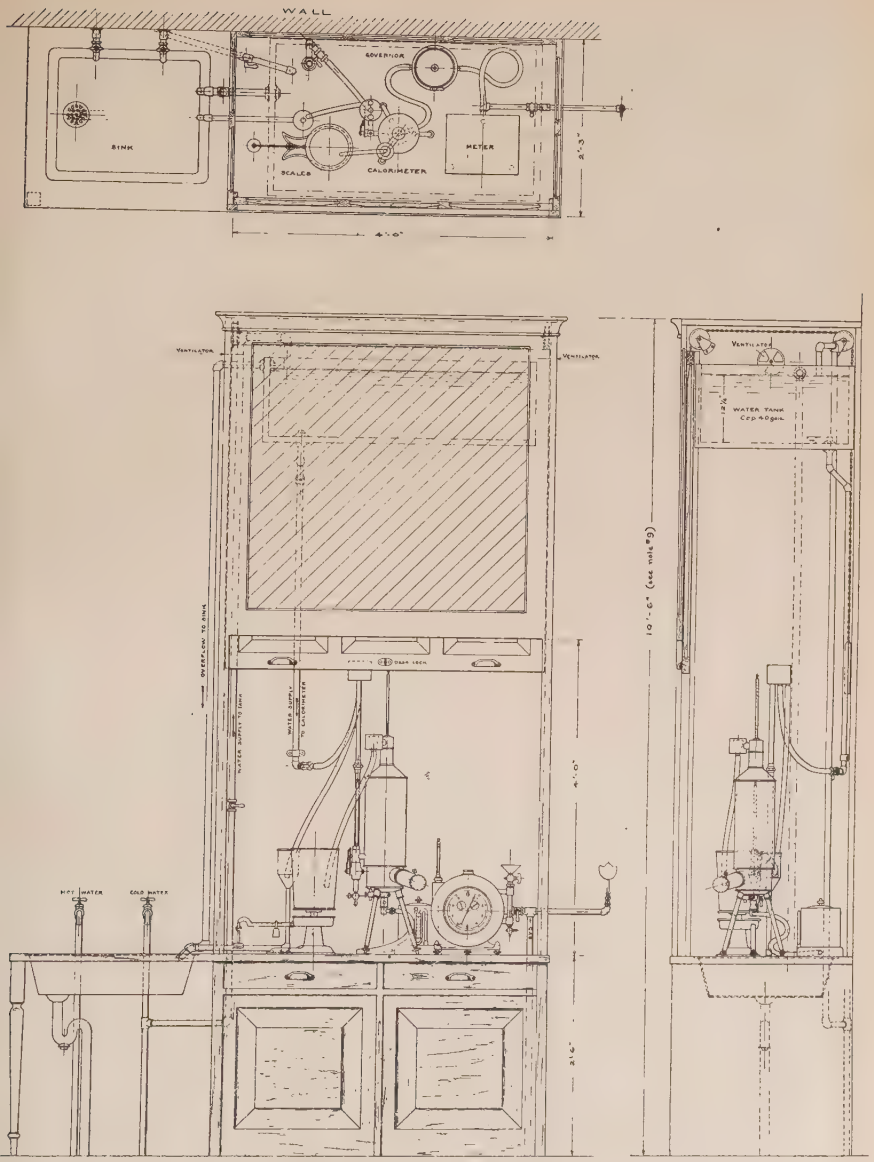
Used luminous flame.

TABLE 23.—SERIES AN.—(*Continued.*)

Graefe Calorimeter.

	7	8	9	10	11	12	13
Barometer	29.00	29.00	29.00	29.00	28.98	28.98	28.98
Temperature of gas	80.8	80.8	80.9	80.9	81.0	81.	81.
Room temperature, °F..	81.	81.	81.	81.	81.	81.	81.
Exhaust temp., °F. ...	124	123	....	116	121	123	150
Height flame, cm.	3	3	3	3	3	4	4
Gas consumed, liters ...	2	2	2	2	2	2	2
Water heated.....	1000	1000	1000	1000	1000	1000	1000
Initial temp. .....80.73°F.		80.73°F.	80.83°F.	80.96°F.	81.08°F.	81.303°F.	81.584°F.
Final temp. .....93.54°F.		93.59°F.	94.25°F.	93.935°F.	94.627°F.	106.690°F.	106.126°F.
Rise of temp. .....12.81°F.		12.86°F.	13.42°F.	12.975°F.	13.545°F.	25.387°F.	24.542°F.
B. T. U.	400.0	401.5	419.0	405.1	422.9	396.3	383.1

Used non-luminous flame.



CALORIMETER CABINET

NOTES REGARDING CONSTRUCTION AND OPERATION OF CALORIMETER CABINET.

This sketch represents a typical calorimeter cabinet, suitable for use in wareroom or shop or rear of gas office, and of such design that the calorimeter when once placed and connected up may be kept clean and safe and ready for use at all times.

The construction of cabinet should be as dust tight as practical. Where there is not enough head room for vertical sliding door, horizontal sliding or folding doors may be substituted. For lower ceilings, the cabinet should be made as high as possible, keeping tank in same relation to top of cabinet as shown; and sliding door can be made in two parts, divided horizontally and hung like double sash in a window. Sides of cabinet are shown with glass to enable the interior to be well lighted.

The cabinet may be easily constructed with sink and water supply on either side, and calorimeter may be placed in any position to suit the observer.

Gas supply line to calorimeter should have purging gas jet continually burning, so that a fresh sample of gas may always be obtained. This jet may be conveniently placed as shown, to assist in lighting cabinet. Do not place this light inside of cabinet.

Where city water contains scale or dirt, Distilled Water may be used over and over again. This is conveniently done by placing a receiving tank in base of cabinet. After readings are made pump this water back to overhead tank.

Overhead water tank should be refilled immediately upon finishing any one set of readings, so that the water may have an opportunity to approach the temperature of the operating room before another set of readings is taken.

This cabinet is adapted to any similar type of calorimeter and arrangements may be made for measuring the water instead of weighing it.

All cocks controlling gas and water supply should be

inside of cabinet, and cabinet should be kept closed and locked when not in service.

PLATE XIII
Series 2
Joule 12
Curve showing variation of Heating Value with rise of outlet water temperature.
Junker Calorimeter #872.
Temperature difference F° between Water Inlet and Outlet
Q T H per cu ft

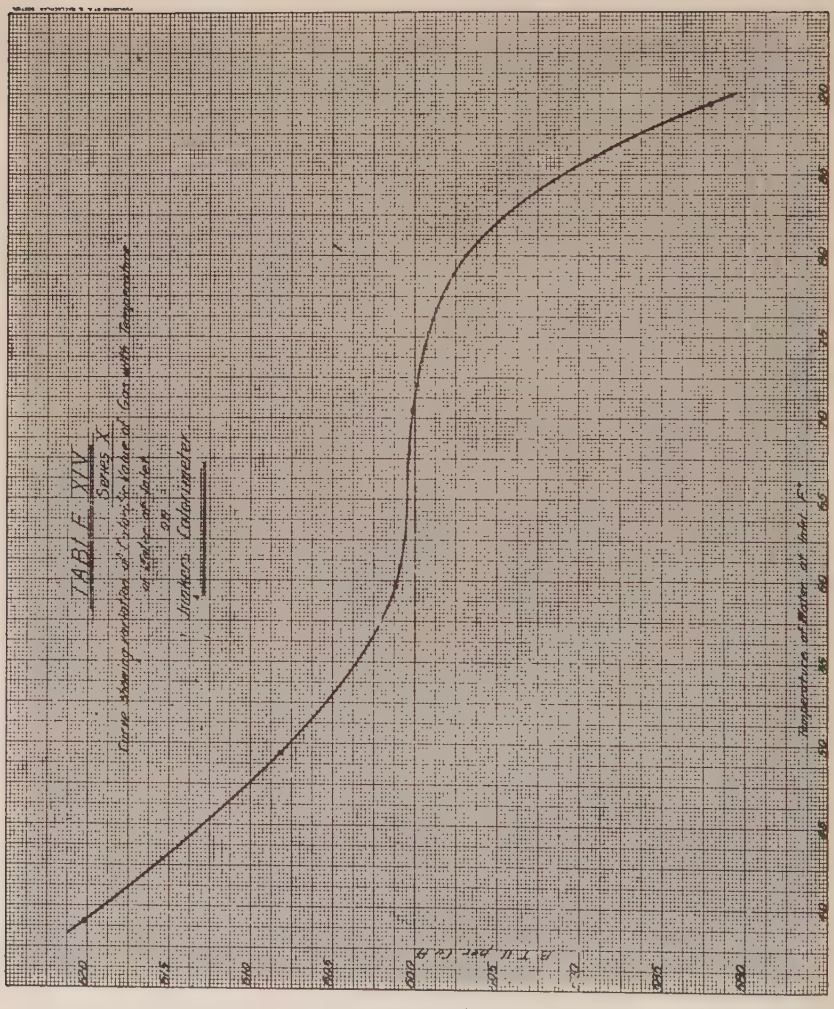


TABLE XIV
Series X
Curve showing variation of Calorific Value of Gas with Temperature of Water at Inlet
28
Junkers Calorimeter
Temperature of Water at Inlet F°
B.T.U. per Cu. Ft.
40
45
50
55
60
65
70
75
80
85
90
820
815
810
805
800
795
790
785
780

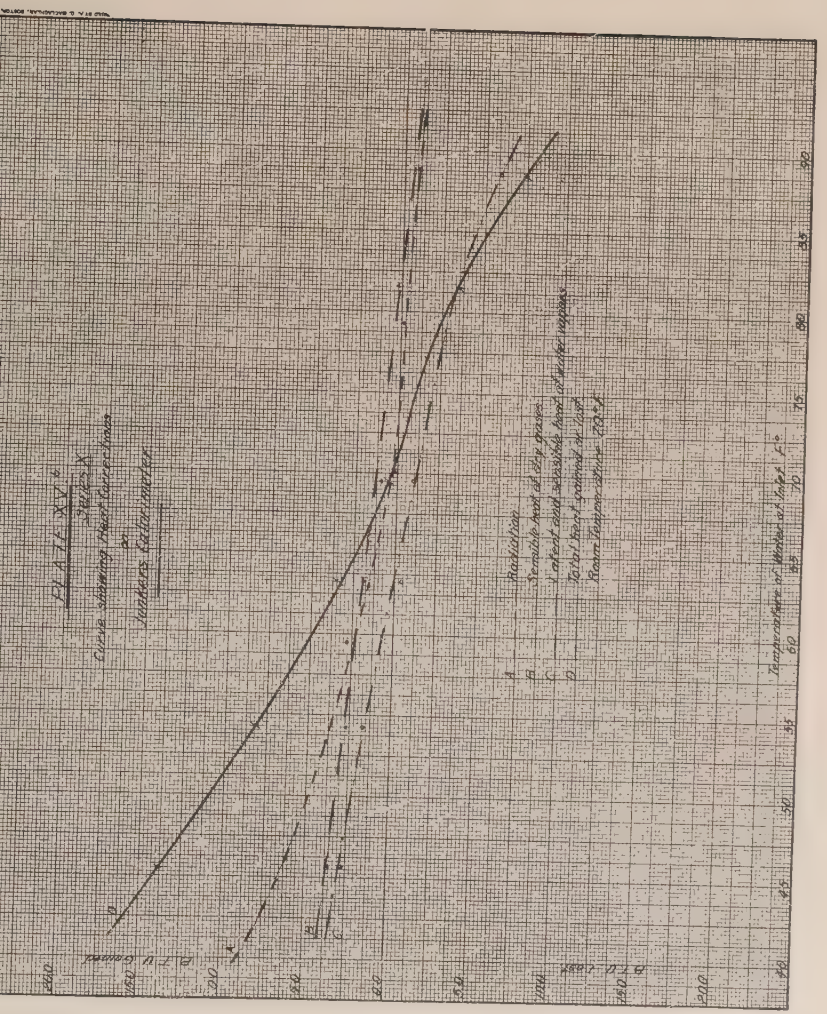


PLATE XV b
Series X
Curve showing Heat Corrections
on
Junkers Calorimeter
A Radiation
B Sensible heat of dry gases
C Latent and sensible heat of water vapors
D Total heat gained or lost
Room Temperature 20° F
Temperature of Water at Inlet F°
B.T.U. Gained
B.T.U. Lost

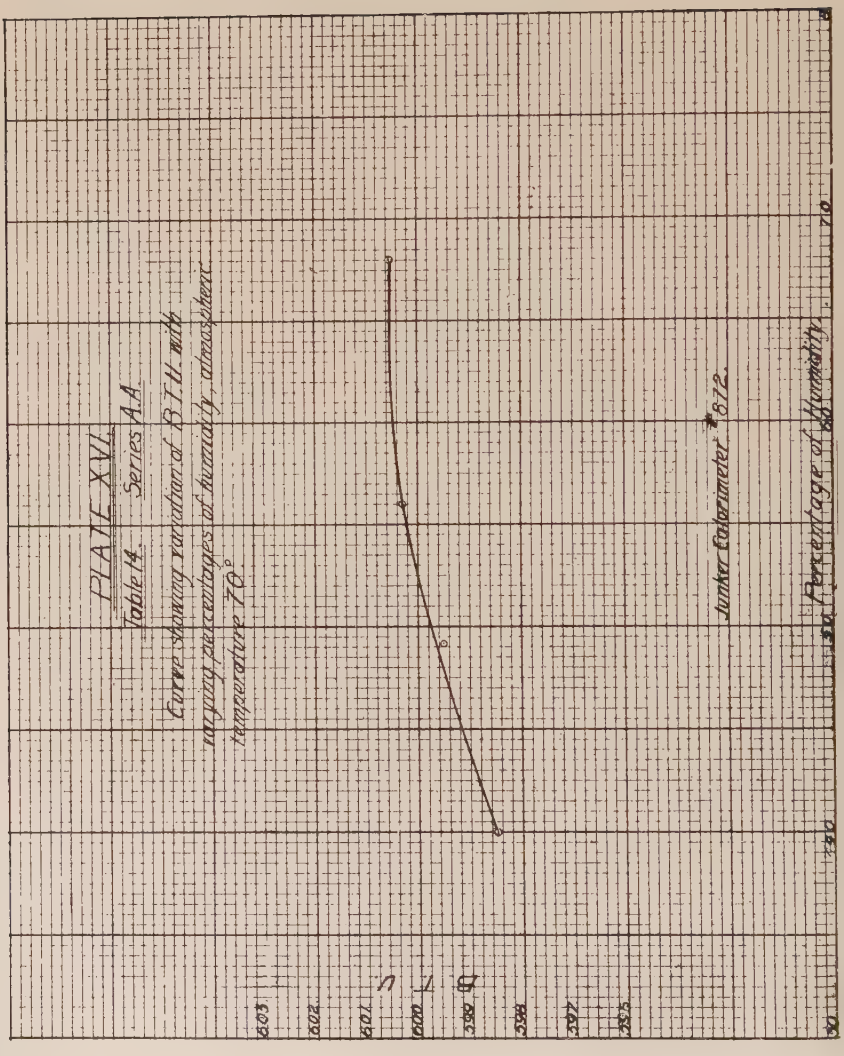


PLATE XVI.
Table 14. Series A.A.
Curve showing variation of B.T.U. with
varying percentages of humidity, atmospheric
temperature 70°
603
602
601
600
599
598
597
596
595
B. T. U.
Junker Calorimeter #672.
Percentage of Humidity.

PLATE XVIII
Calculated curve showing variations of heating value with varying percentages of humidity, atmospheric temperature 70°F
Humidity Per Cent
0
25
50
75
100
B.T.U. saved
B.T.U. added

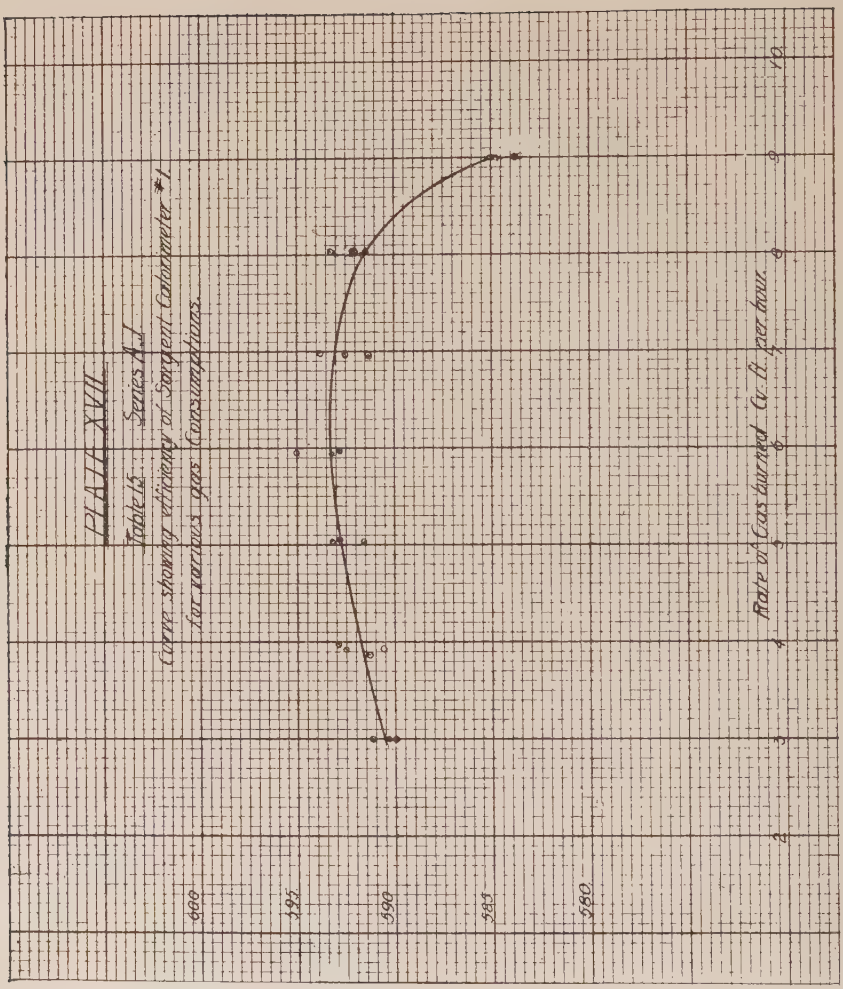


PLATE XXIII.
Table 15. Series A-1
Curve showing efficiency of Sargent Carburetter #1.
for various gas consumptions.
600
595
590
585
580
Rate of Gas burned Cu. ft. per hour.
4
5
6
7
8
9
10

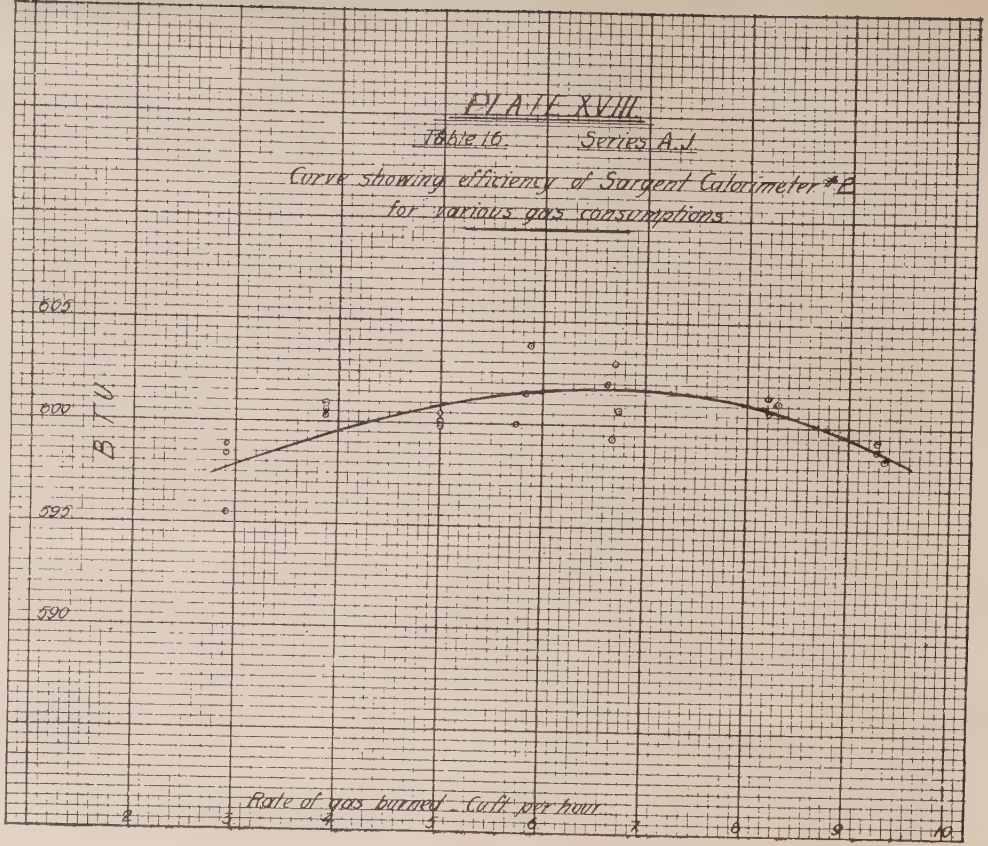


PLATE XVIII.
Table 16. Series A.J.
Curve showing efficiency of Sargent Calorimeter #2
for various gas consumptions.
605
600
595
590
B.T.U.
Rate of gas burned - Cu.ft. per hour.
3
4
5
6
7
8
9
10

THE PRESIDENT: You have heard the report of the Committee on Calorimetry. What action shall be taken?

MR. MCDONALD, of Louisville: I move that it be approved and the Committee continued.

The motion was seconded and carried.

THE PRESIDENT: Next we have the report of the

DELEGATES TO THE INTERNATIONAL PIPE THREAD CONFERENCE

MR. R. B. BROWN: Mr. President and Gentlemen,—On behalf of the Delegates to the International Pipe Thread Conference, I submit the following brief summary of the work which has been done since last year's meeting.

Our delegates found it very difficult to make the foreign delegates to the congress see any good, sound reason for our fractional pitches. 11½ threads, for instance, is the thing they seem to have struck the hardest on. The foreign delegates also believe that the 8-thread pitch in a number of sizes is too large, cutting too much out of the thickness of the pipe.

The Technical Committee would suggest to the Institute that it authorize the President to appoint an American member of the Committee with the view to carrying out the suggestions and recommendations of our delegates to the last congress.

To the Chairman of the Technical Committee, American Gas Institute.

INTERNATIONAL UNIFICATION OF PIPE THREADS.

Sir.—We have now the honor to submit our report showing the progress of the Commission organized by La Société Technique de l'Industrie du Gaz en France for the International Unification of Pipe Threads for Gas Appliances.

To this end, we append a Memorandum by Mr. Vander Willigen, giving a somewhat detailed account of the work of the second Congress in Paris on June 8, 9 and 10, 1909. Mr. Vander Willigen's Memorandum is accompanied by seven appendices, and a blue print.

Through the courtesy of Mr. Laurence V. Benét, delegate

of the American Society of Mechanical Engineers and Hon. Vice-President of the Congress, we are also able to include his valuable report of July 13, 1909, to the American Society of Mechanical Engineers.

Summary and Conclusions.

1. *Profile and Taper of Thread*: With regard to Profile and Taper of Thread, it will be seen that the American Briggs System has been completely accepted; hence, *full effect has been given to Paragraph* 1 *of the Resolutions adopted at the last meeting of the American Gas Institute.*

2. *Diameters*: Although supported by the influential delegate of the American Society of Mechanical Engineers, we have thus far been unable to obtain the modifications in diameters, which were recommended in Paragraph 2 of our Resolutions, in order to make the proposed international sizes interchangeable with existing American standard diameters. Indeed, the situation in this respect is now less favorable than last year, for the 17 mm. size has been reduced to 16.5 mm. and the 60 mm. size has been reduced to 59.5 mm., making them no longer interchangeable with ⅜″ and 2″ pipes respectively. This question is further complicated by the fact that the Commission has adopted the new British *principle* of "gauge diameters," without an exact and specific definition of "gauge diameter" as applied to the proposed International System.

3. *Pitches*: The Commission has finally decided upon a pitch of 2.30 mm. (eleven threads per inch) for diameters from 33 mm. to 114 mm. inclusive, thereby adopting the British standard, instead of the American pitches of 11½ threads per inch from 1″ to 2″, and 8 threads per inch from 2½″ to 4″.

4. In view of the sound arguments to that end of the majority of the Commission, and of the wish of the National Tube Works to reduce the pitch of these larger pipes (see Page 2 of the Report of the Delegate of the A. S. M. E.),

your delegates recommend that the pitches as adopted by the Congress be conditionally approved by the American Gas Institute, and that the entire American influence be concentrated upon securing, as far as possible, *diameters* that will be interchangeable with our Briggs standards.

5. It is important that the American case should be presented forcibly and positively at the next meeting of the Commission; so, to that end, we advise that a third member, resident in America, be added to our delegation (or, as it would then be, *Committee*,) who could co-operate with the Committee on Pipe Threads of the A. S. M. E. and consult with the leading pipe manufacturers. Your "foreign" delegates (if continued) would then be correctly instructed as to the "irreducible minimum" of the position they should maintain at the conferences.

Respectfully submitted,

A. G. Glasgow,
T. A. Vander Willigen,
Delegates.

(Mr. Vander Willigen's Memorandum and Appendices, together with Mons. Benét's report and the other exhibits connected with this subject, will be kept on file at Institute headquarters.)

Mr. McDonald, of Louisville: I move that the in-coming President of the Association be requested to appoint the committeeman suggested by the delegates.

The President: You will have to move the acceptance of the report.

Mr. McDonald: I also move the acceptance of the report.

The motion was seconded and carried.

The President: Next is the Report of the Trustees of the Gas Educational Fund, Mr. A. E. Forstall, Secretary. Will Mr. Walton Forstall read the report?

Mr. Walton Forstall then read the report as follows:

Eleventh Annual Report of the Trustees Gas Educational Fund to the Subscribers to the Fund.

To the Subscribers to the Trustees Gas Educational Fund:

Gentlemen:—The Trustees appointed at the Twenty-Sixth Annual Meeting of the American Gas Light Association, held October 17th, 1898, to administer the Educational Fund formed by your subscriptions, submit the following report as to the work done from October 1, 1908, to September 30, 1909.

As was noted in the last report most of these subscriptions previously in force expired with the beginning of the year covered by this report. The Trustees regret that in spite of a number of personal appeals and a general appeal contained in a circular letter addressed to all the Active Members of the American Gas Institute, they have not been able to secure a renewal of all of these expiring subscriptions, and that there has not been secured an amount of new subscriptions sufficient to meet the full cost of carrying on the work of the Correspondence Class during the year. It has therefore been necessary to draw on the Surplus Fund accumulated in previous years to the extent of $498.27. It is to be hoped that further subscriptions will be made and that in the next year it will be possible to add to the Surplus Fund instead of depleting it.

The idea of building up this Surplus Fund has been that in the course of time it would become large enough for the income derived from it to meet the expenses of the work and thus render it unnecessary for the Trustees to seek new subscriptions every few years. It is desirable therefore that in addition to the subscriptions for current expenses subscriptions should be made direct to the Surplus Fund so that this can be built up more readily than if it depends solely upon the unexpended balances of subscriptions for current expenses.

The publication of the volume containing all of the answers sent out to the different sections of the class has proceeded more slowly than was estimated at the beginning of the year on account of the careful checking of proof both by the Secretary and by the Chairman. The matter is practically all in

type, however, and unless further unexpected delay occurs the book should be issued before the beginning of 1910.

During the year eighteen members of the Section of 1909 finished their course and their connection with the class ceased, while the Section of 1912 started work on January 1, 1909, with a membership of forty-eight.

The number of members in each section at the beginning of the year, the changes that have taken place during the year, and the names of the members of the class who have completed the course during the year, are shown in detail on the Secretary's report, which is appended.

The Section of 1910 now contains twenty-three members, the Section of 1911 twenty-nine, and the Section of 1912 fifty-one, making the total membership in the regular class one hundred and three. Five special students are receiving the questions and answers with the Section of 1912.

The card index of the principal articles published in the American Gas Light Journal, *Progressive Age*, and the *Journal of Gas Lighting* has been kept up during the year.

It may be advisable to remind the subscribers that at the office of the Secretary, No. 58 William Street, there is a room conveniently located in the downtown business district which is available for their use in case, when visiting New York, they wish to arrange for meeting friends or business associates at some place other than their hotel.

The Treasurer's report, which is appended, shows the total amount of subscriptions to date, the available income and expense for the year, a summary of the cash account and the statement of the amount of the surplus fund and the securities in which it has been invested.

The Surplus Fund is made up of a contribution of $2,000, of subscriptions paid in in advance of the time when they are due, of unexpended balances and of interest received on investments. The proper portion of the advance subscriptions will, of course, be drawn out each year to meet expenses, but the unexpended balances and the interest will accumulate into a fund which

will be available to assist in carrying on the work in case all the present subscriptions are not renewed when they expire.

Respectfully submitted,

Trustees Gas Educational Fund,

WALTON CLARK,
Chairman.

ALFRED E. FORSTALL,
Secretary.

SECRETARY'S REPORT FOR YEAR ENDING SEPTEMBER 30, 1909.

	Section of 1909	Section of 1910	Section of 1911	Section of 1912	Special 1911	Class 1912	Total
Members enrolled Oct. 1, 1908...	19	33	49		4		105
Entered Class Jan. 1, 1909				48		1	49
Additions to Class since Jan. 1, 1909				38		4	42
	19	33	49	86	4	5	196
Resigned since Oct. 1, 1908 ...		1	2	6			9
Dropped for non-receipt of answers since Oct. 1, 1908	1	9	18	29	4		61
Finished course during year...	18						18
	19	10	20	35	4		88
Total enrollment Sept. 30, 1909		23	29	51		5	108

Applications on file for admission to class Jan. 1, 1910....26

Names of Students who Completed the Three Year's Course with the Section of 1909.

T. S. Barlow, New York, N. Y.
Reginald Bickford, Syracuse, N. Y.
C. F. Brunt, Waterloo, N. Y.
F. C. Butler, Portsmouth, N. H.
Wm. C. Cocker, Ardmore, Pa.
Raymond A. Fancy, Newton, Mass.
W. R. Goudy, South Bend, Ind.
Merrill C. Hancock, Rockford, Ill.
G. M. Harrison, White Plains, N. Y.
A. A. deLinde, Chicago, Ill.
Harry F. Melvin, Chicago, Ill.
E. D. Minard, Newark, N. J.
S. B. Palmer, Boston, Mass.
John V. Perry, Charlottsville, Va.
David E. Robinson, Philadelphia, Pa.
Walter Sturdevant, Philadelphia, Pa.
Geo. Wehrle, Chattanooga, Tenn.
C. O. G. Witmer, Des Moines, Ia.

Report of Wm. R. Beal, Treasurer, for the Fiscal Year Ending Sept. 30, 1909.

Condition of Subscriptions.

		For year 1908-1909
Total old subscriptions holding over from second five-year period.....	$ 753,00	$ 344.00
Total new subscriptions received for third five-year period since Sept. 30, 1908	17,540.00	3,283.00
	$18,293.00	$3.627.00

Received from subscribers since Sept. 30, 1908	$ 6,442.00	
Payments not applicable to year	3,199.00	
Total paid in by subscribers since Sept. 30, 1908, and available for year	$ 3,243.00	
Paid in previous to current year on account of 1908-1909 subscriptions	244.00	
Total paid in by subscribers available for this year	3,487.00	
Still to be paid for this year	140.00	
Total subscriptions available for year		$3,627.00
Dues received for membership in Special Class		25.00
Total amount available for year		$3,652.00

Statement of Income and Expense.

Total amount available for year		$3,652.00

Expenses.

Secretary's salary	$ 3,000.00	
Office rent	300.00	
Printing, stationery, postage, etc.	784.01	
Periodicals and binding	38.48	
Fire insurance on books	13.03	
Total expenses for year		$4,135.52
Deficit on current expenses		$ 483.52
Depreciation on furniture		14.75
Total deficit on year's operation		$ 498.27

Cash Account.

Received from subscribers since Sept. 30, 1908, Current Fund	$ 5,442.00	

Received from subscribers since Sept. 30, 1908, Surplus Fund	1,000.00	
Interest on securities owned as scheduled under heading "Surplus Fund"	310.00	
Interest on deposits in bank	96.09	
Dues received for membership in Special Class	25.00	
Payment in advance for "Catechism of Central Station Gas Engineering in the United States	20.00	
Total receipts for year	$6,893.09	
Cash balance from last year	2,562.74	
Total to account for		$9.455.83
Expenses for year paid	$ 4,135.52	
Expenses for previous year paid	49.42	
Omaha Gas Co. 1st Mtg. 5% bonds	1,000.00	
Furniture (extension to files and cases for same)	30.00	
Cuts for volume of questions and answers	14.43	
Total paid out		$5,229.37
Balance		$4,226.46
Balance in Knickerbocker Trust Co., as per pass book	$ 1,721.37	
Balance in Guaranty Trust Co. of N. Y., as per pass book less checks unpaid	2,505.09	
		$4,226.46

Publication Account.

Receipts.

For payments made in advance for copies of "Catechism of Central Station Gas Engineering in the United States"	$ 20.00	

Expenditures.

Cuts to illustrate book	14.43	
Balance		$ 5.57

Surplus Fund and Investment.

Amount paid in by subscribers in advance	$ 2,438.00	
Amount paid in by subscribers to Surplus Fund	2,000.00	
Unexpended balances previously reported (after deduction of amount, $55, of subscriptions previously included, but cancelled later; see minutes meeting Oct. 8, 1907)	4,499.79	
Unexpended balance from 1907-1908 (after deduction of amount, $40, of subscriptions previously included but cancelled later; see minutes of meeting Oct. 8, 1907)	450.11	
Interest on bonds to date	2,257.22	
Interest on deposits in bank	378.25	
		$12,023.37

Already Invested.

$2,000 Binghampton Gas Works, 1st Mtg. 5% bonds	$ 1,930.00	
$1,500 Atchison, Topeka & Santa Fe R. R. General Mtg. 4% bonds	1,513.75	
$2,000 Omaha Gas Co. 1st Mtg. 5% bonds	2,000.00	
$1,500 New Gas Light Co. of Janesville, 1st Mtg. 5% bonds (guaranteed by the United Gas Improvement Co.)	1,500.00	
Furniture	140.46	$7,084.21
		$4,939.16
Balance of Publication Account		5.57
		$4,944.73

New York, October 15, 1909.

We, the undersigned members of the Finance Committee of the Trustees Gas Educational Fund, have this day examined the books and accounts of William R. Beal, Treasurer, for the year ending September 30, 1909, and have found the same to be correct, and the above balance of $4,226.46 to be in bank.

ALEX C. HUMPHREYS,
W. F. DOUTHIRT,
Finance Committee.

THE PRESIDENT: You have heard the report of Trustees. What action will you take upon it?

The motion was made, seconded and carried that the report be accepted.

THE PRESIDENT: Next is the Report of the Committee on Beal Medal. Are they ready to report? Mr. Perkins is the Chairman. (No response).

The President: Next is the report of the Committee on Pipe Standards. Has Mr. Brown anything to say?

Mr. R. B. Brown: The Committee on Pipe Standards will not make a report. On behalf of Mr. Miller, the Chairman, who is not present, I will state that a large amount of work has been done on this pipe standard matter during the current year. Several sets of plates have been prepared, and one, the final set, is now in the hands of the pipe founders. We were not ready to meet the committee in conference in time to make any report. Mr. Miller's work has been somewhat delayed by his change in location this year. But I think, while substantial progress has been made, we are not in shape to make any definite recommendation. The committee will undoubtedly be continued, and the work which has been done this year will be of substantial advantage to the next committee in completing the work.

The President: Apparently, no action is necessary. We have here a very cordial invitation from the Michigan Stove Company to visit their plant during our stay in the city. (President reads letter dated Oct. 1, 1909, from the Michigan Stove Co. to the Secretary.)

Is there any further business to come before this session? If not, a motion to adjourn is in order.

A motion to adjourn was made, seconded and carried.

The meeting adjourned at 12.35 p. m.

AFTERNOON SESSION.

The meeting was called to order by the President at 2.30 p. m.

The President: Will Mr. Walton Forstall kindly read the paper on "The Sliding Scale," by Mr. A. E. Forstall?

Mr. Walton Forstall then read the paper.

"SLIDING SCALE" REGULATION OF PRICES AND RATES OF DIVIDEND FOR GAS COMPANIES.

The early recognition of the fact that all men, and not especially those from Missouri, have to be "shown," that is,

must learn from actual experience rather than from the example of others, is indicated by various ancient proverbs. Such a necessity seemed reasonable when only inadequate means existed of ascertaining the exact facts as to the experience of others and the results of this experience, but seems very unreasonable whenever, as is now usually the case, it is possible to obtain complete information in regard to the history of the development of an industry in the country in which it originated and the method of conducting it which this development has proved to be the best of those known at present. Nothing, however, shows greater inability to profit by the experience of others and in this way save the disastrous results of repeating experiments which have failed than does the development in the United States of the control of the prices charged and the rates of dividend paid by gas companies.

In spite of the facts that the business had already had in Great Britain a history covering about fifty years when it began to become of importance in this country, and that the teachings of this history were recognized and proclaimed by the leaders on the technical side of the industry many years ago, the gas industry here was allowed, or rather forced, to parallel the experience in Great Britain.

This had shown unlimited competition between gas companies to be detrimental not only to the companies but also to the communities served by them, but nevertheless such competition was advocated and put into effect in this country as if it were perfectly untried. Only after the goal of low prices for gas had been placed at a much greater distance and rendered much more difficult of attainment by the excess of investment necessarily involved in competition between gas companies, was the next stage reached.

This stage was practically that of maximum price and maximum dividend which had already been tried in Great Britain, and largely discarded in favor of something better. Again was this experience ignored, and for the last twenty years the

method of regulation followed in the United States has been, with only one important exception, that which Great Britain began to discard in 1875. Only within the last five years has any general consideration been given to the adoption in our country of the system of regulation which has been in satisfactory operation in Great Britain for over thirty years.

This system is that of the "sliding scale." It consists in the determination for each company of the proper initial or standard price for gas and rate of dividend upon the stock and the provision that for unit reduction or increase in the price of gas the rate of dividend may be increased or shall be decreased by a definite amount. The theory is that the initial price being such as will enable the company under fair management to earn and pay, and to continue to earn and pay, the initial rate of dividend, the incentive to, and the reward of, management sufficiently better than fair to make possible a reduction in the price is found in the increased rate of dividend which can then be paid if earned, while on the other hand, with poor management it is impossible to continue paying the initial rate of dividend by increasing the price. The community on the other hand, since it is only entitled to the results of fair, average management, benefits by the reduction in price secured by better management and is not made to suffer all the loss resulting from poor management. Practical working in Great Britain for thirty-four years has shown that the theory is correct and that the sliding scale system furnishes a community of interest between company and consumer which is not reached in any other way. Even in the few cases where the incentive afforded by it has not proved sufficient to produce the better management, neither the community nor the company has occupied any worse position than would have been occupied under any other system of regulation that has obtained in the United States. It would therefore seem that the adoption of the system was not only advisable but imperative if the greatest benefits derivable from the industry for both consumers and companies are to be obtained.

It is essential, however, that the basic quantities of initial price, rate of dividend and amount to which this rate is to apply, and the relation between change in price and change in rate, shall be fairly determined in each individual case. In Great Britain this determination is made by committees in Parliament appointed at each session to consider and report upon the "Private Bills" by means of which all "statutory" gas and other companies are originally incorporated and also obtain authority to raise such new capital as is required from time to time. These committees hear evidence from the promoters and opponents of each bill as to the probable cost of gas, the value of the property and the reasonable rate of return upon this value, and after consideration of this evidence, fix the initial rate of dividend and the initial amount of capital upon which this rate may be paid. The relation between change in price and change in rate of dividend is made practically the same in all cases, the customary rate of variation being one-quarter of 1% for each change of one penny or 2 cents in price. The committees also determine the amount of new securities which may be created and issued from time to time to raise the capital required for the extensions of plant needed to meet the demands of the business. These new securities are authorized in advance of the need of issuing them to such an amount as is estimated to be sufficient to provide for the demands for from ten to twelve years to come. They can be issued as the company sees fit, but since they must all be sold at auction and cannot be issued to stockholders at par, there is no temptation to issue them in advance of the need for the money.

Since no equivalent of the Private Bill Committees is found either in Congress or in the Legislature of the various states, the adoption of sliding scale regulation in the United States would involve the selection of the body by which the basic quantities of the system are to be established for each company or its creation in those cases where no suitable body is now in existence. In states possessing public service commis-

sions, the work would properly be included among the duties of these commissions either by virtue of their existing powers in regard to the fixing of rates, if these are sufficiently broad, or by means of suitable amendments to the acts authorizing them. Such amendments should contain merely the general authority, leaving the application to individual cases entirely in the hands of the commissions. In states which do not already possess such commissions, it would seem as if it would be necessary to create them in order to put the system into effect, since the legislatures have neither the time nor the ability to conduct the investigations into the circumstances of each individual case that must necessarily be had before the basic quantities can be determined correctly.

The legislatures already have the power to regulate rates and what is here advocated is merely the delegation of this authority, to be exercised in accordance with general rules laid down by the legislatures, to bodies which, if properly constituted, are more competent for the purpose than the legislatures.

The determination of the proper initial price, the proper initial rate of dividend and the proper amount upon which to allow the payment of this rate at the start involves practically the same investigation of the circumstances of each case as is necessary for the fixing of the proper rate under present methods of regulation, but with these quantities properly fixed, there would be no occasion to repeat the process as must now often be done.

This fact of the practical permanence of the initial price makes it essential that this price when fixed shall contain a margin for contingencies beyond the control of the management, such as increase in price of gas-making materials, and shall also be such as to recognize and reward management better than average where it exists. In British practice the contingency element is recognized by permitting the company to earn in addition to the amount required to pay the initial, or any increased, rate of dividend, extra amounts which can be set aside yearly to an Insurance Fund at the rate of 1%

of the paid up capital of the company or added to the amount carried forward into the next year's accounts until this amount is equal to that required to pay the dividend for a full year at the rate corresponding to the price then charged. The amount carried forward can be used to pay dividends when these are not earned and thus helps to take care of fluctuation in prices of materials, but the Insurance Fund can be used only to meet extraordinary claims and damages arising from accidents which "due prudence and management" could not have prevented, nor can it exceed a total equal to 5% of the capital of the company.

A careful following of the hearings on the bills of gas companies and the action of the committees after these hearings, as reported at great length in the "Journal of Gas Lighting, etc.," has left the impression that there are few, if any cases, in which the initial price incorporated in the company's Act has not been higher than that at which it was selling gas at the time, thus placing the company in a position to pay a higher rate of dividend than the initial one if it could earn it at the existing price. In view of the invariable practice of complainants in rate cases to advocate the fixing of a price based upon the, from their standpoint, most favorable view of the expenses of operation for a single year, this necessity of providing for accident and contingencies and rewarding existing good management must not be lost sight of in the adoption of sliding scale regulation.

The initial rate of dividend and the initial amount upon which this rate should be paid are to a great extent dependent upon each other, and the relation between them can be varied widely without affecting the interests of the community provided that the product of the rate and the amount does not exceed the amount produced by a fair rate of return upon the value of the property. This fact has been recognized in Great Britain by the conversion in the case of a number of companies, of stocks entitled to an initial dividend of 10% and an actual one of from 12% to 14% into an amount of stock

entitled to an initial dividend of 4% or 5% which would yield the same total amount of dividend. That is, a 10% stock would be converted into twice the original amount of 5%, or 2½ times the original amount of 4% stock. The variation in the rate of dividend for unit change in price would also be reduced in the same proportion. Provided the total amount which can be paid in the way of return upon the investment is properly fixed, it is also true that the division of this total between interest on bonds and dividends on stock, either preferred or common, has no effect upon the interests of the community as a body of gas consumers. These points can be settled therefore with a view solely to offering the greatest attraction to the investment of capital in the business consistent with the proper application and efficient administration of the system. The latter consideration would seem to require that in issuing new securities, after the rate or rates of dividend upon the securities authorized at the time the system is applied have been fixed, a definite relation shall be maintained between the amount of stock subject to the provisions of the sliding scale and that of whatever securities of other descriptions the company may be authorized to issue. For instance a company might be permitted to issue equal amounts of bonds bearing a fixed rate of interest and of stock subject to the sliding scale for its rate of dividends, or the issue of bonds might be limited to one-half or one-third the amount of stock. It is very desirable that all stock subject to the sliding scale should carry the same rate of dividend and the necessity of having this rate such as to make the stock an attractive investment without having it so high as to cause the stock to sell at too great a premium should be borne in mind when fixing the amount of stock which is to be authorized when the sliding scale is first applied in any particular case.

While the amount, character and rate of interest borne by the securities authorized for immediate issue when a company is put under sliding scale regulation is immaterial to the community, it is important that the total annual amount of

interest and dividends be fairly and correctly fixed. It would seem that the most equitable method of doing this would be to pay no attention, at first, to the securities actually outstanding at the time, but to value the property of the company as a going concern and determine the proper rate of return upon this value. From these factors, the total annual return to be allowed is determined.

The value as a going concern would necessarily include in addition to the value of the physical plant and working capital an allowance for the value of an established business which, although it is as real an asset as a stack of retort benches or a gas holder, is commonly called an intangible asset because its value cannot be measured in exactly the same way as can those of the different parts of the physical property.

The rate of return to be allowed initially upon this value should be determined separately for each individual case, since no one rate can be taken as being fair under all conditions. In all cases, however, it should be higher than the rate at which bonds or preferred stocks of gas companies can be sold since it is impossible to secure all the money needed for the establishment of a gas plant and its business by means of bonds and preferred stock bearing the ordinary rates of interest. Some of this money cannot be obtained unless there is a practical certainty that it will in the long run, return more than the rate of interest that can be secured by investment in the bonds or preferred stocks of well established companies, whose net earnings available for interest and dividends are much larger than the amount of bond interest or preferred dividends. This larger rate of return is expected to be secured with ordinary management and must be recognized therefore in the initial rate of return, the reward for management better than ordinary being obtained by the increase in rate of return as the price of gas is reduced.

The rate of return upon the capital required for the extension of a well established business, after the company has been put under the sliding scale will take care of itself if provision

is made that the sliding scale securities are to be sold at auction at or above a price to be fixed in advance of the sale, and that all premiums received from such sale at prices above the par value of the securities are to be applied to the extension of the business but will not be entitled to a return. As the business becomes sufficiently established to be attractive to capital at a lower rate of interest the price at which the stock can be sold will be increased and the actual rate of return upon the money put into the property will decrease.

If, as previously indicated, part of the capital is raised by preferred securities assured of a fixed interest which by reason of being certain can be made smaller than the rate of return properly expected as an average on the whole investment, the ordinary sliding scale stock can be given a correspondingly higher standard rate of dividend and can be made more attractive without in any way prejudicing the interests of the consumers, or the community as a whole. This is so because consumers and community are affected only by the total amount collected from them in the shape of return on any given amount of capital invested in the business, and are not at all concerned about the way in which this total return is divided, by mutual agreement, between the different persons furnishing the capital.

The fixing of the extent to which the rate of dividend on stocks under the sliding scale shall change for unit change in price of gas would seem to deserve more careful consideration than has been given to it in Great Britain. Under the provision that the rate shall always change one-quarter of 1% for each change of a penny in price the proportion borne by the total amount of extra dividend allowed the stockholders to the saving accruing to the consumers has grown steadily smaller until in some cases it is as small as one to six, or even one to seven. The result of this has been to decrease the incentive to achieve further reductions. A special committee appointed by the House of Commons in 1899 to inquire into the "Powers of Charge conferred by Parliament on the Met-

ropolitan Gas Companies and to report as to the Method in which these Powers have been exercised" advised that as an extra incentive "a secondary or additional scale be imposed which should permit of an increase or decrease of dividend over and above that regulated by the present scale of ¼ per cent. for every complete 3d. of decrease or increase below or above the standard price of 3s. 3d." The South Metropolitan Company adopted this suggestion in a modified form, but it has not been put into force in the exact shape proposed by the Committee.

There is no good reason why the savings effected by the management better than average should not be divided equally between the consumers and the company, not only at prices for gas near the standard price but also at those far removed from the standard. This equal division cannot be exactly obtained by any fixed relation between change in rate and change in price, unless the amount of securities under the sliding scale is always the same per 1,000 cu. ft. of gas sold. This amount will, however, vary from year to year and tends to decrease constantly, not only because the actual investment per 1,000 cu. ft. of gas sold tends to decrease as the business is built up in any given community, but also for the reason that as the rate of dividend increases and the securities command a premium part of the investment required will be supplied by the premiums and, therefore, will carry no return.

In order that there shall be an equal division of the saving in spite of changes in the amount of sliding scale securities outstanding per 1,000 cu. ft. of gas sold per year, it must be provided that a change of 1 cent in the price of gas shall carry with it a change in percentage rate of dividend to be obtained by dividing 1 by the number of dollars of sliding scale stock outstanding per 1,000 cu. ft. of gas sold in the year immediately preceding. Thus if there were say, $4.00 of sliding scale stock per 1,000 cu. ft. of gas sold, the rest of the investment being represented by securities with fixed rates of interest and priority of claims, the rate of divi-

dend would change one-quarter of 1% for each change of 1 cent in the price, while if the sliding scale stock were $3.00 per 1,000 cu. ft. with more of the other securities in proportion, the rate of dividend would change one-third of 1% for each change of 1 cent in the price. Under such regulation the company and the consumers would each receive one-half of any saving effected by the energy and skill of a management better than average, and this equal division would continue no matter how the relation between investment and sales varied nor how this investment was divided between fixed rate and sliding scale securities.

By the method outlined above the sliding scale system could be applied to the regulation of any gas company with no disturbance of existing conditions unless the company were earning more than a fair rate of return upon the value of its property, and even in such a case the disturbance would be no greater than if the ordinary form of rate regulation were applied.

In Great Britain an official audit of the accounts of companies under the sliding scale must be made, and their approval by the auditor obtained, before any dividends can be declared. In the only case of sliding scale regulation in force in this country no such official audit is included but the company is required to publish its accounts each year in one or more of the newspapers of the city, and has had its accounts audited by public accountants before making this publication. It would seem therefore than an official audit is not an inherently necessary part of the system.

It is not necessary that companies should come under sliding scale regulations when first incorporated. In fact it would be a very difficult matter to accurately fix the basic quantities, upon which the success of this system depends, for a company starting business in a new territory. The business must have been carried on for a sufficient length of time to have become fairly well established before it is for the best interests of either company or community that the sliding scale be applied

to it. In Great Britain all of the companies now under sliding scale regulation had been in existence for many years before it was applied to them, and many of the smaller companies are still working as limited liability companies without any statutory rights. The advantages to be derived from the application of the sliding scale are sufficient to ensure that if it has been generally and fairly applied to the established companies, the new companies that may be formed will take steps to come under it as soon as they have passed the formative period and reached such a position that it is possible to fix a fair standard price and rate of dividend for them.

As will be seen no attempt has been made in this paper to formulate a complete detailed scheme for the application of sliding scale regulation to American conditions in the gas business. This can be done only by the combined efforts of men skilled in the gas business and men skilled in the art of making laws. It is hoped, however, that the general statement which has been made of the way in which it seems to the writer best to handle the salient features of the problem, with the discussion of this statement, will furnish material that can be used to advantage when the detailed scheme is formulated.

In an appendix will be found a brief history of gas legislation in Great Britain, and extracts from various Acts appling the sliding scale and auction clauses.

THE PRESIDENT: Has any gentleman any remarks to make on the sliding scale?

MR. A. M. BARNES: Mr. President, I have read, with a good deal of interest, Mr. Forstall's paper on the sliding scale, and, having had some experience in endeavoring to procure a general sliding scale bill in Massachusetts for the past few years, it has occurred to me that certain points in our experience in Massachusetts might be of interest to the Institute, in connection with this paper. Mr. Forstall says, "With these quantities properly fixed, there would be no occasion to repeat the process, as must now often be done."

A sliding scale bill that was introduced in Massachusetts on behalf of the Association of Massachusetts Gas Companies, provided as a tentative measure, a period of 25 years. That was very strongly objected to, and objection was made even to a period of ten years, but it seemed to be evident, from expressions of opinion that were given at that time, that it would be practically impossible to pass any sliding scale bill without some limit of time during which there should be an opportunity for a revision of the relation of the price to dividend, in case of improved methods of manufacture, or changes in cost of materials.

He also states that, "It would seem that the most equitable method of doing this"—this is, of fixing the rate of interest—"would be to pay no attention at first to the securities actually outstanding at the time, but to value the property of the company as a going concern, and determine the proper rate of return upon this value." And he includes in the value as a going concern an allowance for the value of the established business, which, although it is as real an asset as a stack of benches or a gas-holder, is commonly called an intangible asset. It was on that very point that we met the most determined opposition on the part of the opponents of the bill before the Massachusetts legislature. Several self-appointed guardians of the public conscience appeared there to look out for the interests of the public, and they were very bitter in their opposition to any plan which involved a capitalization or a determination of the amount, as Mr. Forstall calls it, of the established business in the total value of the property. In Massachusetts—and I presume in a great many other localities—gas companies have from time to time accumulated more or less of a surplus from the earnings of the company. There was decided opposition to allowing any return whatever to the stockholders upon so much of the property as was represented by the surplus earnings of the company. One gentleman appeared there and called it "a most iniquitous bill." Another man called it "grand larceny," the idea being that the return upon the property should be no more than upon the

amounts actually paid in by the stock holders. Some even objected to allowing a fair rate of interest upon the premiums paid in. Doubtless you know that in Massachusetts, when any new stock is issued by the gas companies, it is issued at the market value; and there were some there who held that even any premium which went in was not entitled to the same return as the original capital. There would be, I think, in almost all communities an objection to the idea that any one rate would be taken as fair under all conditions. I think any gas manager in the business would think that he was entitled to as much return upon his property employed in the business as any other manager. These are a few points that occurred to me in reading the paper over.

THE PRESIDENT: Is there any further discussion of this paper? It is an extremely important subject. It is a matter upon which some of the Public Relations Committee ought to be prepared to speak.

MR. FORSTALL: With reference to what was said as to the impossibility of getting more than a limited term for the sliding scale arrangement, of course, in England, they have been able to get practically unlimited terms, but that does not mean that, because the arrangement, when made, is made without any fixed term, that body that makes it cannot change it if necessity arises. This would seem to be the common sense standpoint, if we can get the public educated to see it our way. Perhaps in ten years they may want it changed, but they can always change it, because their commission would always have the power, as I take it, to make changes. From the standpoint of a gas company there would seem to be no reason for making the arrangement necessarily terminate at the end of ten years, because possibly at the end of ten years there would be no necessity for termination.

As far as the question about proper allowance to be made for the value of the concern, I think that, and a number of other features my brother speaks of, are simply cases for the proper education of the public, if we can do it. I think

his point is that he believes thoroughly in the sliding scale, and, with that belief, the best thing for the gas companies to do is to start in and try to educate the public up to the proper application of the sliding scale.

THE PRESIDENT: Mr. McLean has made a study of this subject, and we should be very glad if he would explain to us his views.

MR. MCLEAN: Mr. President, I was asked this morning to contribute something on Mr. Forstall's paper, and I have made a few notes. These are mostly to amplify points I observed in Mr. Forstall's paper. Some plan of profit-sharing seems to offer the most practicable solution of the rate question, and I believe the sliding scale plan the most equitable yet tried or proposed.

The sliding scale plan as in operation in England, in justice, requires some modifications to suit American conditions. For example, the allowances for hazards should be increased to meet the greater hazards of the business which arise in America from several sources.

If we are to continue to enlist private capital in public service enterprises, we must have allowance for interest, depreciation, and insurance, which will impress such capital as sufficient. In prescribing the standard rate of dividend, it should be recognized that our business is subject to strenuous competition, involving risks, some of which are taken merely to satisfy the consumer and avoid the appearance of monopolistic arrogance.

In this country we may be confronted also with the question whether the profits, if any, in excess of stipulated returns, shall be shared with the patrons or with the public treasury. At Chicago the Street Railway Companies share with the public treasury. At Kansas City, Cleveland, and elsewhere, directly with the patrons, in the form of concessions in rates of fare. The labor unions prefer the Kansas City plan, and point out that the Chicago settlement means nothing for the non-property owner. Whether the Kansas City plan, or the sliding

scale, is the one best calculated to serve the interests of the gas company depends upon several things, among them the form in which its capital is represented, whether largely in stock or largely in bonds.

But some profit-sharing plan is the vital thing. The question whether the profit-sharing shall be with the public treasury, or with the consumer, is of minor importance. No company should decline an opportunity to establish a plan of profit-sharing, because the representatives of the people demand a division of profits with the public treasury instead of with the consumer.

Opinion is commonly based on preference or prejudice, not upon evidence; therefore, the demonstration such as a sliding scale may afford that the profits of a particular public service corporation are not excessive by comparison with returns in other lines of business, would afford the corporation no complete guarantee against further public attack. Yet, the sliding scale narrows opportunity in this direction to the minimum. It is the best means yet devised for allaying public suspicion of extortion and excessive profit, and for quieting the demand for charter restrictions, so often made in consequence of this suspicion, or for political purposes, or with a view of forcing municipal ownership by making conditions for private enterprise intolerable.

Considered with a view to financial results for the company or the public, the sliding scale may offer no better adjustment than a specific rate, subject to review at the will of the rate-making body; but it is vastly better as a means of avoiding agitation, designed to distract the attention of the voter from other issues, and which—if it does not result in litigation—expensive alike to the company and the public, at least disturbs the investor's sense of security in the permanency and the safety of his investment.

Undoubtedly a state public service commission, familiar with the questions that arise in a rate controversy, would facilitate the successful and satisfactory operation of the sliding

scale compact; but the institution of such a scale need not await the creation of such a commission in the state now without it. It would suffice to repeal the statutes existing in some states which provide that the right of the city council to regulate rates at any time shall not be abridged by contract. Subject to approval by the people, that body should have authority to make a contract, giving the sliding scale legal effect during the life of the charter, whether the same be for a definite or an indefinite period.

If a sliding scale were adopted, no state commission would be needed to adjust rates. And if a plan insuring to the consumer, or to the public treasury, a share of any returns above fixed charges and standard dividend would not avail to protect public service companies against raiders, and the ever-recurring political agitation of the rate question, it is not a reasonable assumption that a state commission would do so.

The President: Are there any further remarks on this subject? If not, I will ask Mr. Butterworth to read his paper.

Mr. Butterworth then read his paper:—

TECHNICAL AND MECHANICAL PROGRESS IN THE GAS INDUSTRY DURING THE PAST 12 MONTHS.

Large bodies move slowly, and it could hardly be expected that radical and revolutionary advancements would be made in the technique of an old and established industry like ours during the short period of one year. Nor will the mention of any such steps of progress be found in this report. However, when we come to examine carefully the developments in each branch of the engineering and mechanical divisions of our business during even the short period of the last 12 months we find that in the aggregate a satisfactory, creditable and encouraging increment of progress has been made.

Unfortunately it is difficult for the contemporary historian to discriminate between the new things that are destined to be permanent improvements and those that are only heralded as such but that prove after experience to be valueless. Many

claims of progress are controversial for the first year or two. In the following notes therefore (which are by no means exhaustive), care has been exercised, so far as possible, to record as advancements only those things that seem actually to be such; although, to show the trend of effort toward progress, and as matters of interest, some things that look promising have been mentioned simply for what they are worth, as having been "brought out" or invented. Whether they will prove permanently useful to our industry must be left to the future.

It will also be noticed that, whatever may be said as to the superiority of American commercial or business-getting methods in the gas business, our technical progress seems to originate, for the most part, in Europe, chiefly in England and Germany.

In the Appendix following this report will be found a list, as complete as possible, of books on technical subjects pertaining directly or indirectly to the gas industry, published in any language, during the past 12 months, the object being to indicate the present tendency of thought along the technical lines of our business. For the same reason the Appendix contains also a classified list of all papers on technical subjects connected with the gas industry that have been presented at any gas association meeting, the world over, since the date of the last meeting of this Institute. In the Appendix are also classified lists of all patents issued during the year in the United States pertaining to the gas business, and of those issued in England that have been deemed worthy of description by the "Journal of Gas Lighting," the purpose of which is to show the present trend of invention in our industry.

The attempt has been made to enumerate the following points of progress in the order of their importance.

Carbonization of Coal.

There has been world-wide interest and activity during the past year in all matters pertaining to the study of the

problems of coal carbonization. The gas journals have teemed with discussions of this subject, the technical schools of Europe and the Universities of Illinois and Michigan have made and reported experiments of much value bearing upon it, and the Technological Department of the United States Geological Survey has also added its quota of findings. Scientists have disputed as to the course followed by the gas in its passage from the coal through the retorts or ovens, with the view of determining the best construction for minimizing the injurious after-effects of heat upon the evolved gas, and engineers have experimented to ascertain the most economical and efficient systems. As a result we have to-day the choice of many different methods of carbonization, including ordinary horizontals and inclines, inclines at an angle of 45°, verticals (both continuous and intermittent), chamber-ovens of various sizes and positions, combined coal and water-gas retorts, etc. In Germany the feeling prevails that the days of the ordinary horizontal and inclined systems are numbered, and that the star of the verticals and chamber-ovens is rising. As the result of the success of the latter with long-hour charges, engineers operating ordinary horizontals and inclines have been stimulated to make the most of these systems, and have found that by increasing the size and duration of the charges they are able to get better results in yield and candle-power of gas and quality of coke. This practice is therefore being generally adopted, and the placing of inclines at the greater angle of 45° is the outgrowth of this experience.

By-Product Coke Oven Plants.

The by-product coke-oven industry is coming into closer alliance with the gas industry with each succeeding year. More cities, both in this country and in Europe, are adopting coke oven gas, to a greater or less extent, as their "town gas" supply. In the city of Indianapolis a by-product plant has just been erected for the primary purpose of supplying gas to the city, and in Chester, Pa., a by-product plant has been diverted from its original purpose of making coke as its chief product,

to the principal business of making illuminating gas. The by-product works at Hamilton, O., have been doubled in capacity, the one at Detroit has been enlarged, a new plant is now building in Gary, and a large iron and steel company has just contracted for one in Canada, to have a carbonizing capacity of 1,000 gross tons per day. It has been suggested that a possibility of the future is the manufacture of practically all gas throughout the thickly populated portions of the country at a comparatively few central points in large by-product plants (which are only a modified vertical retort or chamber oven), and the high-pressure transmission of the gas through pipes to the intervening cities and towns. However that may be, it is certain that the by-product coke oven system is making headway, and it is hardly too much to say that it has made greater technical progress recently than has perhaps any other branch of the gas business. The developments at Chester above referred to are especially interesting and significant. Here the modified plant saves all the gas for sale (after enrichment with benzol); uses no more coal and produces no more coke than ordinary retort benches yielding an equal quantity of gas; utilizes the small and inferior coke for producer gas making, and all, or any desired portion, of the tar, to good advantage, for heating the oven flues; while the coke produced is of course suitable for metallurgical purposes and therefore commands a higher price and wider market. A block of this type has been installed in Detroit.

There are 3 or 4 by-product coke oven systems in use, and all of them have made technical improvements during the past year. The extraction of ammonia from the gas by converting it directly into sulphate has been referred to in another place. One system has worked out a novel application of both recuperators and regenerators for preheating either the air, or both the gas and air, as may be desired. The use of silica materials in oven construction has been adopted, with most excellent results. A washer-cooler apparatus for cooling and scrubbing the gas has been put into successful use, that is not only highly efficient but occupies a remarkably small space.

Notable progress has been made in benzol enrichment, in the direction of a better understanding of how to treat the gas to insure the proper absorption and retention of the benzol vapor in cold weather. This is effected by thoroughly drying the gas and removing certain interfering hydrocarbons. The gas is so scrubbed, also, that the last particles of tar mist and naphthalene vapor are removed, and for the proper manipulation of the gases in exact proportions the Venturi meter has been developed and applied with very satisfactory results.

Chamber Ovens.

Probably the most remarkable feature of the gas industry during the past year or so is the rapid development and adoption of "chamber ovens," a system or carbonization intermediate between ordinary retorts and by-products coke ovens, designed and used primarily for the manufacture of gas, and therefore employing coke for fuel instead of gas. Although Klonne made an unsuccessful attempt at a chamber setting at Schalke as long ago as 1892, and Dr. Bunte pointed out their promising possibilities in 1894, the first successful experiments in their construction were made late in 1901, by Ries and Schilling, at Munich. After a few years of experimenting in a small way, quite a large installation was built in 1906, which has been running almost constantly ever since. As the result of its success, chamber ovens have been erected by several different concerns and on several different designs, until now there are such plants in Munich, Konigsberg, Leipzig, Berlin, Hanan, Zwickan, Rindorf, Frankenthal, Ratisbon, Hecklingen, Halberstadt, Vienna, Bochum, Dortmund, Rotterdam, Hamburg, Regensburg, Padua, Rome, Paris, Norwich, Staffordshire, and possibly other cities. The last two of these are in England. Most of these installations have been erected within the past year or two, some probably being yet uncompleted, and considering their novelty, and their radical departure from ordinary construction, their introduction has been astonishingly rapid. This is all the more strange for the reason that apparently these chamber ovens have not thus far shown markedly better results as a whole than those obtained by the usual re-

tort methods. The "Journal of Gas Lighting" sees no great advantage in them except where a better coke is needed. And yet Dr. Lessing, a competent authority, said before the British Institution of Gas Engineers last June, "I have no hesitation in saying that I consider the coming of the chamber setting by far the most important event in the carbonizing branch of the gas industry during the past 12 months." He enumerates their advantages as follows: saving in labor, high yield of gas, good calorific power, little carbon deposit, no stopped stand-pipes, small consumption of bench fuel, little loss through radiation, coke good quality and size, tar thin and free from carbon, small ground space, simple and comfortable manipulation, and long life of plant. He mentions only two disadvantages: low illuminating power and high cost of installation.

Briefly, the chamber ovens are not essentially different in shape and size from by-product ovens, but they are built either horizontally, vertically or inclined (mostly the latter), and are heated with coke instead of with gas. The largest chambers contain 6 to 7 tons of coal. The candle-power of the gas is not above 12, and this may explain the relative slowness of the introduction of chamber ovens into England and elsewhere, where higher candle-power is required than in Germany.

At least one chamber oven concern is now represented in this country.

High-Pressure Lighting.

Recent developments in high-pressure gas lighting constitute probably one of the most interesting and important steps in the progress of our industry, especially as they may point the way in which gas is destined to cope with electricity for its share of the illuminating business. During the past year several gas companies in this country, including those at Boston, Chicago, Milwaukee and Detroit, have experimented with high-pressure gas lighting, with encouraging results, especially when employing burners made for, and properly adapted to, high pressure. In Europe, notable progress has been made in this direction, particularly in Berlin, where, on July 1st of this year, 25 miles of streets were being lighted with 1,531 high-pressure

gas lamps, supplied by 4 separate compressors, with gas at from 53 to 78 inches of water pressure, and giving light, in some cases, of over 4,000 candle-power each. It was stated last April that Berlin had decided to spend 7,000,000 marks, at the rate of 1,000,000 marks (about $250,000) per annum, in installing in all thoroughfares incandescent inverted gas burners under pressure; and that this decision had been arrived at after much investigating and experimenting by competent officials. Fleet Street, London, and some parts of its adjacent streets, and also some fine bridges in that city, are being very successfully and brilliantly lighted in this way, and further extensions of the system are being made and contemplated. Other cities in Germany outside of Berlin, and others in England outside of London, are also beginning to adopt this system of street lighting. In Fleet Street the cost is said to be one penny per hour per 1,500 candle-power of light. In Berlin the consumption for a given quantity of illumination is said to be one-quarter that of the former low-pressure lamps used, and the lighting is said to be very much cheaper than electric lighting, even with the latest types of electric burners.

The Pharos system of high-pressure gas lighting is said to show an economy of 40 to 50% compared with ordinary low-pressure lighting; from 60 to 70% compared with electric metallic filament lamps; and from 80 to 90% compared with carbon filament lamps. The Pharos burners employ no chimneys. The Graetzin type of high-pressure gas burner seems to be the one mostly used in Germany thus far, while the Keith, Sugg, Pharos, Lucas and others are being tried out in England. The Graetzin burner runs as large as 3′ 9″ x 2′ 2″, and gives as much as 4,500 candle-power, with an efficiency as high as 52 candles per foot. Inverted burners are generally used in these high-pressure lamps, and some lamps contain as many as 6 mantles, although usually the Graetzin has 3 and the Keith one. The compressors used for bringing the gas to the desired pressure are very efficient and compact. One delivering 500 feet per hour at 55 inches pressure weighs only 60 pounds. In the Pharos system, either the gas or the air is

compressed, according to circumstances. The Lucas lamp has recently been fitted with a thermo-pile, heated by the burner, which supplies current to a small electric motor mounted in the base of the lamp and carrying a fan which produces the desired pressure. A somewhat similar burner has also recently been placed on the market in France. Only one mantle is used, the candle-power being 1,300 when burning 28 feet per hour, making an efficiency of over 46 candles per foot. This is really not a high-pressure, but a self-intensifying lamp.

The high-pressure lighting now being done in Fleet Street takes in considerable private commercial business besides illuminating the street, the office of "Punch," as early as last February, containing as many as 350 of Keith's 100-candle-power high-pressure lamps, and several other neighboring concerns are also lighted wholly or partially in this way.

Automatic Lighting and Extinguishing of Street Gas Lamps.

So much has been done within the past year or so in the development and perfecting of methods and devices for automatically lighting and extinguishing gas street lamps that this might properly be considered one of the most important steps of recent progress in our business. While it is true that in this country comparatively little street lighting is now being done with gas, this is due in large part to the expense heretofore incident to lighting and extinguishing gas street lamps; and the improvements above referred to have been such as to practically remove this handicap and put this business back within our reach again, especially with the aid of Welsbach burners.

At least 12 different systems for automatically lighting and extinguishing gas street lamps are now in use in Europe and Great Britain, where, of course, gas street lighting is much more in vogue than it is here. Up to the first of last July, 20,000 burners had been equipped with one of these systems. In January last, 30,000 were using another, while as long ago

as last November 28,000 were equipped with still another, and European cities everywhere are rapidly adopting these and other systems and saving, according to reports, about 50% in labor, 30% in mantles, 20% in chimneys and 10% in gas, as compared with methods previously used. Some of these systems employ an independent clock-work device at each lamp, others light and extinguish the lamps by means of a wave of high gas pressure through the mains, imparted at the works or other central point, while still others employ a combination of these two methods. A degree of ingenuity that commands our highest admiration has been exercised in overcoming the many and great difficulties incident to making the "wave" system successful, flexible and reliable; and it is not too much to say that they are now past the experimental stage and have been made practical and dependable. A slight wave of pressure, say only 4 or 5 tenths above the normal, or whatever the delivery pressure may be at the moment, lights all the lamps practically simultaneously, at any desired time, a little earlier on cloudy evenings, etc.; and another wave extinguishes them at midnight or morning, as may be desired. In a trial case, lamps were successfully operated in this way that were as far as 10 miles from the works. A simple but ingenious device prevents the lighting or extinguishing by accidental variations in the pressure, or by the slow increase of pressure due simply to meeting a greater demand for gas at one time of the day than another in the district supplied. In the case of cluster lights, one can be left burning at midnight, if desired, while the others are extinguished, the other then being extinguished in the morning. By adjusting the street lamps differently, those in one suburb can be extinguished while those in another remain burning; or every alternate lamp can be extinguished at midnight if desired, or lighted up earlier in the evening than the others. In short, the wave system seems to have been so perfected as to meet every possible contingency or desire. It is interesting to note that in one of these systems at least, the pilot light at the burner consumes only one-tenth of a foot of gas per hour.

Fire-Clay Goods.

During the past 12 months much progress has been made toward the production of better fire-clay goods. Manufacturers generally have adopted more thorough and scientific methods for improving the quality of their output, one American manufacturer claiming an increase of 100% in the life of his material. Some three years ago a new material for retorts and settings was brought out by a well-known maker of fire-clay goods in this country, and although it gave extraordinarily good results from the start, it is only within the past year that large installations built with this material have brought it into the lime-light as a notably superior product. Owing to the fact that it does not settle under high heats and has a greater conductivity than materials previously and generally used, the results obtained from it in the way of gas yield per pound of coal are quite sensational, running as high as six feet, with no diminution of candle-power, thus marking a noteworthy forward step in our progress, fairly belonging to the past 12 months.

A Committee representing the British "Institution of Gas Engineers" has been co-operating during the past year with the English Ceramic Society in a movement having for its object the standardizing of fire-clay materials.

Original and important experiments have been conducted in this country during the past summer with the view of determining the heat conductivity of different fire-clays under different temperatures, and the results, which are of considerable value to our industry, were reported at the meeting of the Michigan Gas Association last month.

Pressure Control.

During the past year devices for making pressure regulators more sensitive and perfect in their action have been developed by nearly all manufacturers of these apparatus. Heretofore, in the case of district or street main governors for instance, the outlet pressure has risen when the inlet pressure has fallen nearly to that desired at the outlet. A new "pressure control" has been brought out that corrects this defect.

Nor is there any increase in outlet pressure (as has heretofore been the case) when the inlet pressure rises after having been allowed to fall below that which the regulator has been set to produce at the outlet. This device is also made in a modified form that enables it to automatically increase the outlet pressure at times of peak loads, the degree of the increase being determinable. The increase occurs strictly during the peak period, the pressure also varying strictly in proportion to the increase and decrease in the load, rising and falling precisely with the demand. These improvements have also been extended to house governors.

Within the year also a long distance automatic station or district governor has been, it is claimed, so perfected that it is now actuated successfully by the variations in pressure in any selected outlying or distant section of the city, the variations being transmitted to the governor by electricity. The use of the small pressure pipe for the control of district regulators from a point in the distribution system some little distance therefrom, as described at the last meeting of this Institute, has further increased during the year. In short, considerable addition has been made to the refinements of pressure regulation in gas distribution, enabling gas companies, by means of higher pressure, to give even better service than heretofore, with existing distribution pipes, notwithstanding large increases in output.

While some gas managers still contend that the retort house governor, for smothering pressure fluctuations in the retorts due to the working of the exhauster, is of no special advantage, its use is nevertheless rapidly extending, and those using them claim better yields of gas and other important benefits. Many manufacturers of gas works apparatus, both here and abroad, now make these governors, the entirely inclosed and dust-proof type being considered the best. One concern fits the auxiliary cover with a padlock to prevent unauthorized alteration of the weights.

Water-Gas Apparatus.

About a year ago a German process of water-gas manufac-

ture was described, the essence of which is the constant maintenance of a particular temperature in the generator, the result being an increase in efficiency. This is accomplished automatically, the gas pressure at the inlet of the holder actuating a manometer which operates a recording pen and also rings a signal bell. This method of control has been applied during the year to a number of plants in Europe, with excellent results in the way of increased hourly yield and decreased coke consumption. Several companies in this country have within the past year or so installed devices for securing the volumetric regulation of the admission of air and steam in their water-gas generators. They accomplish this by so throttling the generator connection pipe, on the Venturi meter principle, as to cause the pressure fluctuations in the base of the generator, due to the variations in the resistance of the fuel bed, to signal the operator, and, in the case of one company, to automatically regulate the admission of air, the steam being also mechanically measured. This automatic regulation is so much more exact than hand regulation that the result, in actual practice, is a decided improvement in efficiencies, and the device constitutes an invention of great value and importance in water-gas manufacture.

During the past year a form of water-gas plant previously used for making blue water-gas only has been adapted to the manufacture of carburetted water-gas. An English gas company has very recently ordered a tar carburetting water-gas plant, the necessary enrichment to be obtained from tar, which, after such use, still remains suitable for spraying roads. Some French engineers a year or so ago also patented a process and apparatus for making gas from tar, employing 2 generators working alternately, and a syndicate was formed in Amsterdam for working the process.

Gas Street Lighting.

There has been very little change during the past year in either the volume of gas street lighting in this country or the means for such lighting. One concern, however, has brought out a single and double inverted burner fixture for street lamps,

to be used on the ordinary gas pressure. An English firm has put on the market a device for converting the upright burners of street lamps into inverteds.

The tendency of course is toward high-pressure street lighting, but this is being tried so far in this country only in a limited way and in special locations. In Great Britain and Europe, however, conditions are quite different, and there has been considerable progress there during the past year in both high- and low-pressure gas street lighting. England, for instance, has added during that time about 22,000 low-pressure gas street lamps, and now has a total of about 800,000. This increase is doubtless due in part to the success of the automatic lighting and extinguishing systems now coming into extensive use; and it does seem that with these remarkable devices and the wonderful results of high-pressure gas, the street lighting of American cities, as well as those of Europe, may soon again be done, in large part at least, by gas. Berlin already has about 33,500 gas street lamps, many of them of high candlepower and operating under high pressure. That city intends to spend a sum equivalent to about $250,000 each year for 7 years in extending its gas street lighting, until all its streets shall be lighted with gas. Last Spring a deputation of 5 members of the Streets Committee of the City of London were sent, under authority of the Common Council, to eight different cities of Continental Europe to investigate the different methods of street lighting employed therein. They made a very thorough investigation, and in their report recommended "that high-pressure incandescent gas lamps, with inverted burners, should be adopted as the illuminant (for the City of London); but, where gas is impracticable, electricity, with open arc and flaming arc lamps, should be installed.

Vertical Retorts.

Although vertical retorts have been the subject of more interest and discussion during the past year than ever before, and several additional installations of them have been and are being made, yet the technical and mechanical improvements in

these systems have been few and comparatively unimportant. The Woodall-Duckham system (employing continuous carbonization) has, however, been considerably improved by the substitution of an individual coke discharging drum for each retort, which obviates the handling of hot coke and brings the work of each retort directly before the eye of the operator. The Dessau system (intermittent carbonization) has been improved only with respect to the bracing of the retorts.

The three small trial installations of "intermittent system" verticals made in this country within the past year or two, at Manchester, N. H., Columbia, Mo., and Vancouver, B. C., have apparently all been failures, at least as originally constructed, although efforts are still being expended to make them successful. A small installation of the Woodall-Duckham system is now being finished at La Grange, Ill., for experimental purposes, and a contract was recently let for the erection of a large installation of 120 vertical retorts on the Dessau system at Providence, R. I., the plans providing for eventually doubling this number.

The Dessau (or Bueb) system has grown rapidly in favor in Continental Europe, particularly in Germany. There are said to be over 4,000 Dessau vertical retorts now in use, and installations have been made in Dessau, Berlin, Aix la Chapelle, Brussels, Frankfort, Oberspree, Cologne, Potsdam, Bremen, Warsaw, Trieste, Genoa, Rio de Janerio, and several other cities. England has been characteristically conservative in the adoption of vertical retorts, but the Sunderland Gas Company has recently decided to build a plant of the Dessau type, while Woodall and Duckham, after 5 years of patient battling, at the Nine Elms works of the London Gas Light & Coke Co., with the tremendous difficulties of continuous carbonization, have succeeded in so perfecting their system as to secure its adoption also at the Kensal Green works of the same company, and by the Corporation of Burnley. Continuous carbonization seems to appeal to our English cousins as the ideal to be attained, and Glover and West have recently tried out, with excellent results, a comparatively large installation of their

own design on this principle, at St. Helens. An installation that can be worked as either a continuous or an intermittent system will also be put into operation in Edinburg within the next few months, while vertical retort plants on original designs are now in use in Etaples and Lyons, France.

There is a growing feeling that the vertical retort system has passed its experimental stage, and not only has established its success, but bids fair to become quite widely adopted for works making more than 500,000 feet per day, especially when candle-power requirements are not high. While the illuminating power of vertical retort gas is somewhat low, and the furnaces require careful treatment and watching, the system has the following claimed advantages:

Increased yield of gas and ammonia;
Improved quality of coke and tar;
Great saving in first cost of land and buildings;
Less nitrogen, fixed sulphur and naphthalene.
Improved working conditions; and
Less wear and tear of retorts.

The practice of introducing a little steam into vertical retorts for the purpose of making some water-gas, or what is called "wet carbonization," while having some advocates, has not been found by most operators to be advantageous.

Mantles.

The use of incandescent mantles has grown to such proportions that, according to one authority, there were manufactured last year

100	million	in Germany,
55	"	" America,
35	"	" Great Britain,
15	"	" France,
3	"	" Austria,
2	"	" Italy,
2	"	" Belgium,
1	"	" Russia.
213	"	Total.

One new factory in England has a capacity for making 10 million mantles annually. With such large production it is inevitable that every year, including the past one, has brought forth improvements in the machinery and methods for mantle-making, and in the mantles themselves. Ramie mantles are now used very largely in England, although the Plaissetty cotton mantle is employed to a considerable extent for street lighting. High-pressure gas lighting with such lamps as the Graetzin, Keith, etc., has brought about the increased manufacture of specially impregnated mantles for withstanding the high pressures. A new braided mantle, mades of asbestos and ramie, has been brought out recently, for which increased strength and durability are claimed. The most interesting invention is a "metallic filament" mantle, said to be very strong and durable, and to yield 85 candles per foot of gas (probably under high pressure.) It is, however, still in the experimental stage. There is also being tried in England an upright mantle without prop or support—an inverted mantle turned upside down, as it were. There is also a new mantle with a metallic tip, which increases its durability. According to an American authority, the new Ramie mantles are extremely strong, and have long physical and candle-power life, showing an average depreciation of only 10% after 1000 hours' burning. Two or three so-called self-lighting mantles have been brought out during the past year, but although such mantles are a great desideratum in our business, a perfectly dependable and reasonably durable one has apparently not yet been produced.

Last Spring Lieut. Shackleton reported the discovery of new sources of monazite in the antarctic regions.

Lamps and Burners (Low Pressure.)

While no epoch-making inventions have been brought out during the year in the way of low-pressure gas burners, there have been marked improvements made in existing types. The inverted burner particularly has been so perfected that even the "Illuminating Engineer," whose evident preference for lighting effects obtained electrically has often been noted, now admits

that in the quality of illumination there is nothing to choose between gas and electricity, and that gas lighting has kept on a par with electric lighting in respect to appearance. It would be impossible to enumerate here the various improved burners that have been produced within the past 12 months, both in this country and in Europe. Their name is almost legion. The improvements tend to lower cost of maintenance, more sightly appearance, higher efficiency, greater ease, nicety and comfort of adjustment, and greater variety of design and size. An intermediate size of inverted burner, between the usual one and the bijou, is coming largely into use, giving a candle-power of from 50 to 60. The metal parts of burners that are most exposed to the heat are being white-enamelled or given a porcelain or china casing. The bunsen tubes and other parts are gradually being so improved that an increasing proportion of air is drawn into the gas, resulting in increased efficiency. In Germany particularly the inverted burner is rapidly displacing the upright, and the same trend is evident everywhere.

Inverted gas arcs are also being rapidly improved and developed and are becoming popular. They are now easy of adjustment, easily cleaned, and made in a variety of sizes, including short ones for low ceilings. Regenerative and self-intensifying burners are being developed in great numbers, in which the air supplying the flame is pre-heated by the products of combustion. They are very successful and efficient, yielding from 27 to 30 candles per foot, unreflected, and as high as 35 and even 40 candles when the light is reflected In fact, so efficient are these lamps that serious question is being raised as to the wisdom of going into the development of high-pressure gas lighting. The Lucas self-intensifying, single-mantle inverted burner is now made to yield 1,000 candle-power.

Out-door types of lamps have been made more wind-and-rain-proof. A ventilated lamp for florists, etc., has recently been brought out, as has also a so-called "twin light" burner, said to be entirely successful, consisting of an upright Wels-

bach burner immediately over an inverted one, both supplied with gas and air through the same pipe.

Feld Washer.

About a year ago Walther Feld, of Germany, brought out his new system and apparatus for removing (separately) from coal gas its tar constituents, cyanogen, ammonia, and even sulphur compounds, by fractional distillation of the gas, his scheme taking advantage of the different dew points of the various vapors. The Feld washer is regarded as a promising and important invention, and is already being successfully used. It may develop into the solution of the problem of the complete purification of gas in closed vessels.

Calorimetry.

The use of calorimeters in the gas business is rapidly increasing as the result of the growing importance of the heating value and the lessening importance of the lighting value of gas. One well-known Eastern house reports the sale of over 60 calorimeters of one rather inexpensive type within the past eight months. As the result of the increased attention that is being given this subject there is much activity in the invention and improvement of calorimeters, and numerous makes are now on the market. At the Electrical Exhibition at Manchester about a year ago, a new portable calorimeter was exhibited, especially adapted to testing suction producer gas continuously. The same firm has also so improved another of their calorimeters as to provide for neutralizing by weak alkali the effects of the products of combustion on the interior of the instrument, and also for automatically shutting off the gas if the water supply should suddenly cease. The accuracy of their calorimeter is said to be limited only by the skill of the operator in reading the thermometers, and tests can be made in two minutes.

A new recording thermo-electric calorimeter was also described a few months ago in a paper by Prof. Fery before the National Congress of Applied Chemistry, and still another calorimeter was very recently brought out in France and

described in the gas journals of last August. There is scarcely a maker of calorimeters that has not improved his instruments within the year.

New types of calorimeters should however be carefully tested before being used, if accuracy is desired.

Gas Grates and Heaters.

With the constant tendency toward a lower price of gas and a higher price of solid fuel, the gas grate and room-heater become more and more important, especially in view of the increasing number of apartment houses in cities. The percentage of auxiliary house-heating that is done by gas is increasing each year. During the past year much study has been given to the improvement and perfecting of gas grates, or "fires," as they are called in England, particularly in the direction of increasing their radiating efficiency. At the last meeting of the British Institution of Gas Engineers, a previously appointed "Gas Heating Research Committee," working in connection with the University of Leeds, presented a noteworthy and instructive report on the subject of heating with gas. It is becoming recognized that gas grates are even more hygienic than are coal fires. Among the improvements of the past year or so in gas grates are a gas and air regulator for properly proportioning the gas and air supplies; a form of Venturi meter applied to burners for more intimately mixing the gas and air; and a burner that, in itself, without a governor, is said to produce complete combustion and a fixed flame, regardless of pressure variations. Investigations have been made into the relative efficiencies of the different kinds of radiating materials, and the use of the Siemens principle, by which the flame does not impinge upon cold surfaces, is now considered the best practice. Gas-heated hot air registers, or furnaces, fixed in or underneath the floor, are also being improved and are gaining in favor and use.

Industrial Gas Fuel Appliances.

The developments in industrial gas appliances are too numerous and rapid to admit of their enumeration in this report.

Every year widens the field of industrial fuel gas and increases the efficiency and variety of the appliances used. Among the new things recently brought out or greatly improved are

Revolving oven for commercial bread baking;

Water-heating hot-plate fitted on top of gas range;

Oven for lithographing on metal;

Powerful high-pressure blow-pipe, for heavy brazing, melting, etc., superseding the oxygen-acetylene flame for many purposes.

Barium chloride furnace for hardening high-speed steels;

Furnace for case-hardening by cyanide of potassium process;

Case-hardening furnace in which the metal is packed in gas instead of in bone or other solid carbon;

Muffle-furnace for welding bifocal lenses;

Furnace for tempering and coloring, and especially for obtaining the "gun metal" finish;

Bath boiler for fire engine circulator;

Oven for baking heavy cores in foundries;

Furnace that will melt 56 pounds of brass in 20 minutes;

Steamless gas radiator claimed to have a perfectly even distribution of heat over its entire surface.

PRODUCER GAS POWER PLANTS.

The development of producer gas power plants is interesting and important to us because of their competition with "city gas." However, this competition should not be serious for sizes of engines below 30 or 40 H. P., and as there are comparatively few prospective installations larger than this, producer power plants are not nearly as formidable a competitor as the electric motor. It is interesting, however, to note the rapid development of the producer plant, especially for use with cheap and low-grade fuels such as lignite, "bone" coal, mine roofing-slabs, culm, etc. Several such plants are in successful use with peat as fuel, and one or two are using cotton-seed oil, sawdust, etc.

The best available information on the recent development and present status of the producer gas power plant is to be found in the report of Dr. R. H. Fernald, just issued by the U. S. Geological Survey. According to this report there are now about 500 such plants in operation in this country, aggregating about 125,000 H. P., 57% of which is produced from bituminous coal and lignite. While about 88% of the total number of installations use anthracite, those using bituminous coal average 12 times larger. The report states that while the first cost of these plants is high as compared with steam plants (except for the very large sizes), yet their cost of operation is less, resulting in a decided net saving. The suction producer has practically superseded the pressure producer working into a holder.

ILLUMINATING ENGINEERING.

During the year illuminating engineering has strengthened its claim to the title of one of the applied sciences and a distinct profession, the importance of which to the gas industry is coming to be recognized by most gas companies. The American Society of Illuminating Engineering is now a large and active organization.

One of our largest gas companies has retained a Bureau of Illuminating Engineering as Consulting and Designing Illuminating Engineers for designing and redesigning its globes, reflectors, etc., in accordance with the best knowledge of this subject from a physiological and aesthetic standpoint, and most companies are giving more attention to the scientific illumination of interiors than they have ever done before.

TECHNICAL EDUCATION IN GAS ENGINEERING.

Year by year better public facilities for learning gas engineering are made available. Several colleges in this country now have courses bearing especially on this subject, including the Universities of Michigan, Wisconsin and Illinois. In England the Livesey Professorship of Gas Engineering at the University of Leeds has recently been endowed, in the

sum of 10,000 pounds sterling, by the gas industry of Great Britain, as a memorial to the late Sir George Livesey. This University already maintained a department of fuel and gas engineering, and a number of public lectures have been delivered there on this subject, as well as in Edinburg, Glasgow, London, etc. Courses in Gas Engineering are maintained at technical schools in Carlsruhe, Cologne, and several other European cities.

HIGH-PRESSURE DISTRIBUTION.

The past year has added its increment to the growth of high-pressure transmission and distribution, and there is now hardly a gas company of any considerable size that does not employ it to a greater or less extent. This country was the pioneer, and still leads all others, in the use of this system, and in its refinements, but European cities are rapidly falling into line. Many of the compressors and regulators used in England in connection with high-pressure work come from this country, but some very fine machines for pumping gas have recently been produced there.

During the past year there has been a tendency toward conservatism in the application of high-pressure to low-pressure distribution, and the consequent reduction of the percentage of the gas that is subjected to very high pressures. This, however, does not refer to the transmission of gas between town and cities. In Great Britain one company at least is automatically regulating its gas pumping plant by means of a pressure pipe direct from the center of distribution. At the next meeting of the Illinois Gas Association, which is affiliated with this Institute, a paper will be presented on the improvements of the past year in house pressure regulators employed in high-pressure distribution, with the view of making them more dependable in their action, it having been ascertained that the mercury seal with which they are usually provided is not always safe. It was at the last meeting of the Illinois Association also that the valuable results were given of recent

extensive experiments to determine "the effects of compression and transmission on the candle-power and heat units of gas."

The transmission of gas at high pressure through long cross-country mains from town to town is increasing year by year, both here and abroad. In Germany 344 villages are now thus supplied with gas.

PYROMETRY.

Now that high temperature carbonization has come into greater vogue, resulting from the discovery that the most money is made by keeping the heats as high as possible short of injuring the setting, pyrometry has risen in importance. A good and simple pyrometer is a desideratum as a means of enabling the retort house operator to sail as close to the wind as possible in this particular. Several makes are on the market and are being used to a considerable extent, the Fery spiral radiation pyrometer being one of the latest and best developments. A new electric resistance pyrometer was also put on the market a few months ago in this country and is said to be meeting with much favor, as is also the Wanner radiation pyrometer.

METHANE HYDROGEN PLANTS.

These plants have come further into favor during the past year, several of them now being in operation in England as an adjunt to coal gas works, especially in small cities. They make gas out of tar, coke and benzol, and the method of introducing and permanently gasifying the tar is very ingenious and successful. It is likely that this process will come into still further use as a means of profitably disposing of tar and coke. One million feet of methane hydrogen gas takes from the market about 5 tons of tar and 20 tons of coke. At Utrecht a very simple gas making plant is in successful operation using a mixture of ⅔ gas-oil tar and ⅓ water-gas tar.

UTILIZATION OF TAR.

The low price of tar has revived progress in means for burning it economically. A French patent was taken out early

this year for heating and atomizing tar to increase its efficiency as a fuel. Three papers on the use of tar as a bench fuel were presented at the meeting of the French Gas Society last Spring, and one at the meeting of the Italian Gas Society. At the Lea Bridge gas works in England there is in operation a patent cyclone separator for dehydrating water-gas tar by centrifugal action. A similar device is in use in Brooklyn, N. Y., a 3 H. P. motor driving a revolving bowl at the rate of 6000 R. P. M., handling one barrel of tar per hour.

The use of tar for laying dust on roads, and for so constructing roads as to make them dustless, is increasing rapidly, both in this country and in Europe. Experience is gradually showing road builders and public authorities how the tar should be applied, and progress would be still more rapid if they would accept the knowledge gained by the experience of others instead of trying to work out the problems for themselves. The tendency is toward the use of heavier material as a binder for the upper courses of the stone and surface material, which gives more permanent results than surface application only. One large tar concern in this country report an increase this year over last in the quantity of tar used for roadway purposes of 125%, and they estimate that for the year 1909 there will be treated with tar about 1000 miles of roadway 15′ wide. The Roads Improvement Association of England report that last year nearly 1500 miles of English roads averaging 20′ wide were treated with tar.

A tar broom, connected by hose to the hot tar in a portable boiler, has been recently brought out for this work.

The use of water-gas and coal-gas tar as a binder for briquettes is increasing, coal tar being considered the better for general use. In France, from 15 to 40% of the fuel now used by railroad locomotives is in the form of briquettes. Probably the best statement of the present status of the briquetting business is to be found in the magazine *"Fuel"* of August 17, 1909. Individual makers of briquettes have improved their product during the past year, and briquettes made from

bituminous coal and coal tar pitch now stand handling fully as well as anthracite. Briquettes are also now being successfully made of coke breeze.

Ammonia Extraction.

A by-product coke-oven concern in Europe (who are also beginning operations in this country) have brought out a "direct sulphate process" for the extraction of ammonia from by-product gas and its manufacture into sulphate. The gas as made is passed in direct contact with the acid. The system is said to be successful with by-product coke oven gas. Whether it could be successfully adapted to ordinary retort gas works remains to be seen.

An English firm has also brought out a "centrifugal" washer for the extraction of ammonia in the form of ammoniacal liquor. Another has apparatus in operation so efficient that the one man in charge is able to make 10 tons of dry sulphate per 24 hours.

Sulphur Purification.

Experiments were made in Germany within the past year or so with the view of finding some means for cheaply removing CS_2 from illuminating gas by washing it in certain oils and chemicals; but while some success was secured in the laboratory, the process was deemed too expensive for adoption on a working scale. Wood charcoal has also recently been experimented with for the removal of this impurity, with partial success. In Oregon the old abandoned method of reheating purified gas, thus converting the CS_2 into H_2S and then removing the latter in the usual way, has recently been revived, but as the added expense incident to the nearly total extraction of the sulphur thus effected is there about 1 cent per 1000 ft., it is not likely that the method will be very widely adopted, especially in view of the prevailing tendency to relax the sulphur restrictions heretofore imposed upon gas companies. In this connection it is also pointed out that

gas produced in vertical retorts contains about 40% less fixed sulphur than does gas from horizontal retorts.

A patent for an inclined purifier was taken out last December in France, claimed to save labor, and an automatic safety device was brought out in England that prevents the turning of gas into a purifying box unless the oxide discharge doors are all tightly closed. A vertical purifying box, recently put into use in Germany, was also described during the year, for which the claim is made that it saves space and labor.

During the past year there has been a revival of interest in the problem of purification by ammonia and several experimenters are working along this line, with encouraging prospects of final success.

Coke Chute.

That form of coke chute brought out a few years ago in which the hot coke falls from the mouths of the retorts into bins or pockets in, or under, the charging-floor in front of the retorts, and is there quenched by sprays of water from fixed perforated piping and allowed to remain until dry and then dropped out by opening the door below, has come into further and extensive use during the past year.

Bunsen Burners

A Simmance-Abady pressure-gauge capable of measuring to the ten thousandth part of an inch of water has recently been devised, to help in the improvement of the design of bunsen burners.

An ingenious inventor has recently produced a bunsen burner the tube of which contains a vertical spiral wire that oscillates rapidly from the upward motion of the gas and air, thus mixing the mixture still more intimately and so securing higher efficiency.

The Meker bunsen burner, although really brought out a few years ago (in France), has only during the past 12 months become prominently known through the superiority of the line of industrial gas furnaces that have since been gotten

out for utilizing its principle. It is so made that the percentage of air drawn in and mixed with the gas is much more nearly the theoretical proportion for complete combustion than is secured in the ordinary bunsen, thus saving gas and heat and securing higher temperature. An English manufacturer of gas appliances challenges the claim of absolute novelty for the Meker burner, but admits the newness of its design.

During the past year or so a blow-pipe has been brought out in which the air and gas are mixed in proper proportions, regardless of the quantity or shape of flame desired, by rotating two valves in unison, one governing the air and the other the gas supply.

Gas Water-Heaters.

Gas is being used more and more, and with increasing efficiency, for the heating of water for a multitude of purposes, and it is impossible for this report to enumerate the devices that are being developed for such uses.

After several years of experimenting, there was put into use last Spring in England a successful water-circulating hot-plate made for placing on the top of almost any make of gas range, by means of which water is heated with the waste heat from the gas used for cooking. New types of automatic gas water-heaters, in which the opening of a hot water faucet at any place on the hot water piping system connected with the heater opens the gas valve and allows the gas to flow so long as the water runs, have been brought out during the year, and there have also been improvements made upon existing types. One of them is said to have an efficiency of 94%. Water-heaters of this class for domestic use have become thoroughly practicable, dependable and economical. A new French gas water-circulator, for heating rooms, is said to have an efficiency of 80%. An Eastern concern has brought out a portable 8-pound bath water-heater that heats the water by being partially immersed in it while the gas is burning.

International Candle.

One of the important technical advancements of the past year or two is the effort that has been made toward the adoption by all civilized countries of a standard unit of light, to be maintained jointly by the national standardizing laboratories of the United States, France and Great Britain, such unit to be called the "International candle" (or some other suitable name), and to be employed in all photometric determinations, gas and electric included. Although all gas and electric organizations throughout the world are desirous of the establishment of such unit for universal adoption, the difficulty of agreeing upon a satisfactory unit is of course great. The latest developments of this movement are set forth in the report of the committee on this subject at this meeting of the Institute.

Photometry.

Aside from the efforts that have been made for the adoption of an international unit of candle-power, no notable progress in photometry has been made during the year. Studies in this subject were reported last October by Carl Hering to the British Engineering Society, and the National Physical Laboratory of England presented further evidence of the reliability of the 10-candle pentane lamp as a primary standard of candle-power. At the meeting of the German Gas and Water Engineers last summer, Dr. Bunte recommended that photometric tests be dispensed with everywhere, as they had been in Berlin. Flicker photometry has been declared by the Physical Technical Institute of Charlottenburg to possess no advantages over the ordinary methods. Dr. Kruss, of Hamburg, described last Spring a new form of integrating photometer.

Calorific Test.

The increasing tendency during the past 12 months toward the substitution of the calorific for the photometric test for gas, both in this country and in Europe, can properly be considered an advance step in the technical progress of our in-

dustry. The number of companies that are required to furnish gas of a specific heating power is increasing, and the next step should be, and doubtless will be, the removal of existing requirements as to illuminating power. This is also foreshadowed by the prevailing tendency toward a lower candle-power requirement, especially in Europe, and in the actual removal of all candle-power requirements by one State Commission in this country in specifying the quality of gas to be supplied in that State.

Gas Ranges.

There has been a general betterment of detail construction and appearance in gas ranges during the past year, particularly in this country. Closer inspection is being given ranges by both manufacturers and purchasers. There has been an increase in the sale of cabinet and elevated-oven types of ranges. The use of enamelled oven linings is increasing, and the tendency year by year is toward simplicity of construction, interchangeable parts, and a minimum of bolts and screws. One concern in England has brought out a range without a single screw in its body, and it has been taken entirely apart and put together by one man in 17½ minutes. Another English concern has applied the principle of regeneration to the ovens of domestic ranges, preheating all the air for combustion and ventilation by passing it up through spaces surrounding the ovens and so effecting a saving, it is claimed, of 25% in the gas consumption.

Corrosion of Iron.

Much study has been given this subject during the past year, and much progress made toward an understanding of it, although much still remains to be learned about it. Mr. Cranfield, in a paper read last May before the Yorkshire Junior Gas Association, and Mr. Harper in a paper read before the Illinois Gas Association last March, have contributed especially valuable discussions on this subject, including information as to the best measures thus far discovered for preventing the corrosion of iron, either underground or overground, from all causes, including electrolysis.

Reversing Condensers.

A well-known constructing company has recently installed the first "reversing condenser" in this country. Either of two condensers may be placed first. In case of stoppage of the cooler one by naphthalene, the flow of gas may be immediately reversed, turning the hot gas through it. The condensers are so arranged that the tar is extracted between them, irrespective of which may be first.

Meters.

The oil-dipping of meter diaphragms has been more generally adopted, with good results, and improved methods of introducing the oil have been evolved.

Meter provers and "complaint" meters have been improved.

Promising experiments have been made, during the past few months, looking to the devising of a means for accurately and quickly testing consumers' meters *in situ*.

At least one large gas company has recently put into operation in their meter-shop a complete and detailed piece-price wage schedule.

The dictum has recently gone forth from Manchester, Eng., that consumers' meters should be tested for correctness of indices as well as of measuring chambers.

An American inventor has just brought out a simple device, for attachment to ordinary consumers' meters, for indicating and measuring the passage through them of extremely minute quantities of gas. This will be useful for detecting very small leaks in house-piping, etc.

A greatly improved lock for prepayment meter cash-boxes has been brought out, and also a "thief-proof" cash box. A coin-changing attachment for prepayment meters has also been invented.

The use of the rotary station meter seems to be increasing.

A station meter, said to be practicable, has just been brought out that works on the very interesting principle of adding electrically a known quantity of heat to the gas and determin-

ing the quantity of gas flowing by its rise in temperature. This meter may come in good play in measuring high-pressure gas.

Bench Furnaces.

The Parsy bench furnace, invented in 1906, is said to be rapidly coming into successful use in Europe. It is suitable for either large or small works where there is no cellar, everything being above-ground, and is said to be practically as economical as the most complicated and expensive furnaces. Parsy has more recently brought out a novel form of gas producer for his furnaces.

A concern in England is also building and introducing a furnace in which the producer gases are taken up flues in the side walls of the producer, instead of through nostrils in the arch, the secondary air being also taken up in the same way, resulting, it is claimed, in a 20% increase in the duty of the retorts.

In this country, bench furnaces in which a portion of the flue gases are brought back under the grate bars are being improved and more generally adopted.

Gas Holder Construction.

A 3-lift gas holder was recently erected by beginning at the top and working downwards, the crown and upper sheets being lifted by jacks and otherwise as the construction of the lower sheets proceeded, this being the second holder that has been built in this fashion.

The spiral-guided holder seems to be "holding its own," as there are now some 300 in use. A million foot holder of this sort was erected at Montreal a year ago, and one of the spiral-guided holders erected in England during the past year has a capacity of 3½ million feet. In Germany recently several holders with "Intze" tanks have been constructed, in which the holder tank stands over a masonry tank of smaller dimensions. Oil tanks are now occasionally constructed inside of holder tanks, especially those of relief holders. The largest gas holder in Continental Europe has just been finished at Hamburg, with a capacity of 7,060,000′.

Distance Lighting (Local.)

At least 3 systems for the distance lighting of gas in homes, factories, churches, etc., by means of the electric spark, have been brought out in Europe during the past year. A foreign concern making a pneumatic push-button device for lighting and extinguishing gas burners has recently begun making the plungers of steatite, which greatly reduces their unfortunate tendency to stick and cause trouble. There have also been some other improvements of a minor character in this system of distance lighting, but further improvement is greatly needed. The so-called "Norwich switch" has come into considerable use in England, and inventors are still chasing the *ignis fatuus* of that desideratum of our business, a thoroughly satisfactory self-lighting mantle, with some claimed progress as time goes by.

Gas Engines.

The increasing use of producer gas engines has led manufacturers to give more attention, with promising results, to the effect of high compression in the ordinary type of gas engine. The use of larger engines for producer and blast-furnace gases is increasing, particularly in this country. Last August 628 gas engines of 1000 H. P. or over were said to be in use, some of them running as large as 6000 H. P., and one or two are now being built of 8000 H. P. capacity. The opinion has been expressed that such large engines are mechanically, rather than thermo-dynamically, deficient; but internal combustion engines are in better favor to-day than ever before.

The city of Philadelphia already has a gas engine, high-pressure, water-pumping plant for fire protection, and has recently decided to duplicate it in another part of the city, using 10 300-H. P. gas engines, all to use "city gas."

A Washington paper recently reported that the United States Steel Corporation, and also a large New England concern owning a big line of cotton mills, have decided to substitute gas engines for steam engines in all their plants. An article in

Cassier's Magazine for September says that "practical experience has demonstrated that a large gas power plant can be worked with the same immunity from break-downs as a steam plant, and at about one-half the operating cost."

The gas turbine has not yet materialized, although several inventors and scientists are at work upon it.

Charging and Discharging Machinery.

No noteworthy improvements have been reported in these machines during the past year, but minor improvements are being constantly made, and charging and drawing machinery is coming into more extended use each year. This is especially true in the case of small works, machines being now frequently used where for the greater part of the year as little as one ton of coal per hour is handled. The De Brouwer charger has been recently adapted to very small works, and an entirely new manual power machine for charging and discharging has been brought out within the past year in France. A new hydraulic coke pusher has also been put on the market in England within the year. One concern have improved their manual charger by making it much easier to handle, and their power charger so that the chute can be quickly lifted at any moment, irrespective of the position of the carriage. The Fiddes-Aldridge charging and discharging machine has been adapted to serve retorts 5 tiers high, and is so efficient that through retorts 21′ long and carrying 900 pound charges can be discharged and refilled in 30 seconds.

Gas Fixtures.

A large Chicago fixture concern have recently been devoting especial attention to the improvement and making of "straight" gas fixtures; and by making the fittings larger and stronger, and building machinery for subjecting all fixtures to severe air pressure tests, and especially by designing gas fixtures in new and better styles, they have done much good work that merits the support and encouragement of the gas companies. In the designing of ornamental gas fixtures we are being excelled by our English cousins.

Incandescent Lighting Experiments.

During the past year or so, experiments have been made by Arthur Forshaw tending to show that CO is a better constituent of a gas for incandescent lighting than is H:

By Dr. Herbert E. Ives, whose colorimeter indicates that incandescent gas lighting is the best for matching colors;

By M. Jean Mennier on the combustion of gas without flame; and

By M. Sainte Claire Deville on the relation between the heat of combustion of a gas and its incandescent illuminating power.

Last winter there were published the results of careful experiments made at Carlsruhe to determine the relation between the heating value of a gas and its incandescent illuminating value.

Chemical Matters.

The University of Illinois has recently issued a valuable monograph on the subject of the formation of CO in gas producers.

An improved gas burette is described in the "Gas World" of Dec. 26, 1898.

The "Gas World" of March 13, 1909, also describes a direct method of estimating N in gas.

The "Gas World" of May 22, 1909, describes recent work upon the oil "indene," which is found in gas and tar, and which affects the behavior of gas when treated for naphthalene.

During the past year it was discovered that gas meter water contains Prussic acid. ("Gas World," Mar. 27, 1909.)

During the year, Halifax, Eng., decided to install at their gas works a plant for making yellow prussiate.

Experiments have been made that show that at a temperature of about 1,200° C., C and H unite to form methane. ("Gas World," Dec. 5, 1908.)

A well-known firm in this country have recently placed upon the market a new apparatus for the rapid and accurate analysis of gas.

Coalite.

During the past year English gas journals have abounded in references, not always complimentary or sympathetic, to the exploitation that has been going on in England since 1907, but particularly during the past 12 months, of the proposed new fuel "coalite," which is claimed to be an improved coke, suitable particularly for grates, that lights readily, burns brightly and without smoke, and gives out more heat than coal. Its manufacture is described, in the patent covering it, as "a process for the partial destructive distillation of coal at a low temperature, which is arrested at the stage when illuminating gas ceases to be evolved, in retorts 4 to 6 inches in diameter." Vertical iron retorts are used. Last Spring a works for the manufacture of coalite at the rate of 75 tons per day was started into operation at Plymouth, and similar plants have been operated for some time at 2 or 3 other places; but the business can hardly yet be regarded as out of the experimental stage, and its final commercial success is still quite problematical.

Coalexld.

About 18 months ago Mr. Jowett, of Lancashire, England, patented a means for making an improved coke, which he called "coalexld." It is made simply by applying to each ton of coal carbonized in the ordinary way about 1¼ pounds of a preparation composed principally of chlorate of potash, chlorate of soda and saltpeter. The new fuel seems to have made considerable progress during the past year and its popularity and manufacture are apparently increasing, notwithstanding our natural incredulity as to the merits of the scheme.

Gasoline Lighting.

Innumerable "systems" for incandescent lighting with gasoline gas are on the market and in some towns do a small percentage of business in stores, billiard rooms, etc.; but as a whole this percentage does not seem to be increasing. In England the use of "petrol air gas" for these same purposes, and

particularly for the lighting of country places, seems to be somewhat on the increase, although its cost is considerably more than that of "town gas."

Odds and Ends.

A new dip-pipe has recently been brought out in England, for which many points of superiority are claimed. At the meeting of the Irish Association of Gas Managers last Fall a new automatic hydraulic seal was also described.

An improved drip-pot for street mains, essentially simply a a short length of the same sized pipe as the main, but cast with a very deep sag or pocket on the under side, was described last June.

Coke conveyors have been more generally introduced, particularly in smaller works than heretofore. At Dortmund, Germany, the hot coke is conveyed on a belt made of woven wire.

Early this year a German engineering company issued an "album" of 350 pages and over 700 illustrations, describing the latest and best novelties in gas works apparatus.

A new coke "cutter" has been brought out in England, said to cut the coke absolutely uniform in size, is adjustable to various sizes, and produces not more than 5% to 6% of breeze.

A new method and device for automatically weighing coal is described in the "Gas World" of May 22, 1909.

An improved method of determining the sulphur content of spent oxide is described in the American Gas Light Journal of April 6, 1909.

Further study has been given to the possibility of casting, instead of moulding, fire-clay retorts, and some progress toward the solution of this problem has been made.

A new electrically-driven and electrically-governed exhauster has recently brought out in England. Some exhauster-makers in this country have redesigned their machines, making them more suitable for higher pressures.

The use of reinforced concrete for holder tanks is increasing. Among others so constructed recently was one 150′

in diameter at Davenport, Eng., and one 136′ in diameter at Turin, Italy.

A fluted concrete lamp-post for gas street lighting is being tried out in Washington, D. C.

Considerable improvement in the manufacture of oil gas has been made in California, particularly in the direction of the reduction of the percentage of H, and the better utilization of the lampblack produced.

Much new knowledge on the subject of the removal of naphthalene was contained in a paper by Mr. G. F. Twigg, of Derby, Eng., before the last meeting of the Midland Junior Gas Association. The use of naphthalene washers, using solvent oils, is extending.

The German Gas and Water Association recently erected and put into operation an instructional and experimental gas works at Carlsruhe. During the past year it has been self-supporting, and has done much useful work in the way of testing gas coals, etc.

Improved gas leak detectors and gas leak indicators have been brought out during the year, for determining the percentage of gas in a mixture of gas and air, and for not only detecting the existence of small leaks in piping, etc., but for also measuring the exact quantity of gas leaking, however minute.

During the past year the use of lead wool, or shredded lead, for making joints in gas mains, including those used under high pressure, has about doubled. It is said to make a very strong and tight joint, although there is no saving in labor. Lead wire has also been experimented with for this purpose, with very promising results.

Last year nearly 25,000,000 gallons of creosote oil (made from coal tar) was marketed in the United States for preserving timber. In 1904 the quantity was only about 3,500,000 gallons. The Northern Pacific R. R. now creosotes nearly every tie that it lays.

An improvement is said to have been made during the

past 12 months in the process of manufacturing "blaugas", resulting in the saving of losses that heretofore occurred in its manufacture and use.

A certain gas company in this country, in order to overcome trouble from water in its mains, has recently arranged to dry its gas by compressing it under 40 to 50 pounds pressure, before it enters the holders, the water in which is covered with crude oil.

An invention has recently been brought out in England for compressing gas with water.

An experiment, apparently successful so far, is being conducted in the Isle of Wight in lighting railroad coaches by means of ordinary "town gas."

Hydrogen seems to be superseding illuminating gas for the filling of balloons. There was less coal gas used in Europe for this purpose last year than the year before.

A combined gas cooker and circulator was brought out recently in England for utilizing the waste heats of the cooking, and an inexpensive and portable combination cooker and water-heater for small consumers, was also brought out in Buenos Ayres.

Within the past 12 months additional evidence has been added to the already overwhelming mass of testimony as to the wholesomeness of gas lighting from a hygienic point of view.

The practice of buying coal on heat unit specifications and test is increasing.

The use of seamless steel tube mains is increasing and services are being connected to them under high pressure, by expanding the pipe after it enters the main, thus in a sense riveting the service to the main.

The Societe Technique de L'Industrie du Gas en France has offered a series of large cash prizes for improvement in apparatus for making or using gas, incandescent burners,

automatic distance kindlers, domestic uses of gas, appliances for using coke, producers for using gas works coke, etc.

At Worcester, Mass., a retort house was recently erected with a stack of benches at each side of the house and machines between to push out the coke and put in the coal at one stroke.

A well-known manufacturer of pressure gauges has recently developed a differential recording pressure gauge for use in connection with venturi meters in making a continuous record of the volume of gas flowing through a main.

APPENDIX.

I.

Books Published During the Past Year, in Any Language, on Technical Subjects Pertaining to Gas Industry.

(List Compiled by Frederic Egner.)

In the English Language.

Catechism of Central Station Gas Engineering in the United States.

Internal Combustion Engines. By W. M. Hogle.

The Gas Engine. By Forrest R. Jones.

Gas Engine Theory and Design. By A. C. Mehrtens.

Petrol Air Gas. By Henry O'Connor.

The Gas Engine. By Cecil P. Poole.

Suction Gas Plants. By Alfred C. Smith.

Practical Testing of Gas and Gas Meters. By C. H. Stone.

Modern Power Gas Producer Practice and Applications. By H. Allen.

Illustrated Technical Dictionary. Edited by Alfred Schlomann, and a number of co-laborers.

Self-Instruction for Students in Gas Supply. (Section III.)

Calorimetry of Producer Gas. By J. F. Simmance.

The Internal Combustion Engine. By H. E. Wimperis.

Audel's Gas Engine Manual.

The Chemistry of Gas Manufacture (Vol. II). By W. J. A. Butterfield.

Internal Combustion Engines. By R. C. Carpenter and H. Diederichs.

Gas Holder and Tank at Sutton Gas Works. By F. S. Cripps.

The American Practice of Gas Piping and Gas Lighting in Buildings. By W. P. Gerhard.

The Gas Engine. By F. R. Hutton.

Gas Power. By F. E. Junge.

Gas and Oil Engines and Gas Producers. By L. S. Marks and S. S. Wyer.

The Chemistry of Gas Manufacture. By H. M. Royle. (2nd Ed.).

The Gas Engine Manual. By W. A. Tookey.

Gas Works Year Book. Allen & Co., London.

Handbook of American Gas Engineering Practice. By M. N. Latta, (English reprint, 1908).

Town Gas and Its Uses for the Production of Light, Heat and Motive Power. By W. H. Y. Webber.

Fire-Resistive Properties of Various Materials. By Richard L. Humphrey.

Briquetting Tests at the United States Fuel Testing Plant, Norfolk, Va. By Charles L. Wright.

Explosive Mine Gases and Dusts. By Rollin Thomas Chamberlin.

The Smokeless Combustion of Coal in Boiler Plants. By D. T. Randall and H. W. Weeks.

Report of the United States Fuel Testing Plant, at St. Louis, Mo. By Joseph A. Holmes.

Binders for Coal Briquettes. By James E. Mills.

Results of Purchasing Coal Under Government Specifications. By Dwight T. Randall.

General Review of Modern Gas Works Machinery, 1909. By The Berlin-Anhaltische Machinenbau Actien Gesellschaft.

Mine Sampling and Chemical Analyses of Coals. By J. H. Burrows.

Washing and Coking Tests of Coal. By A. W. Belden, G. R. Delamater and J. W. Groves.

Significance of Drafts in Steam-Boiler Practice. By W. T. Ray and Henry Kreisinger.

In the German Language.

Directory of the Gas and Water Industry. By Eisenschmidt & Schulze.

Ammonia and its Combinations. By J. Grosmann.

Architects' and Builders' Handbook. (Refers to gas works). By Kroener, Leipzig.

The Gas-Pipe Layer and Gas Appliances Installant. By Kuckuk.

Illumination in the Past and Present. By H. Hilger.

The Economical Significance of the Gas and Electric Works in Germany. By Leiner, Leipzig.

The Gas Producers and Firing with Gas. By Jaeneke.

The Gas Engine. By R. Schoettler.

Coke-Works and Tar-Products of Gas Coals. By S. Knapp.

Independent Chimneys. (Refers to Gas Works Chimneys). By Frederich Waldau.

The Chemical Industry. By Gustav Mueller & Fritz Bennigson.

Transactions of the Institution of Gas Engineers.

Year Book and Calendar for the Coal Trade and Interested Industries. By O. Polster.

Contributions to the Chemistry of the so-called "Dry Distillation" of Gas Coals. By Dr. A. Bauer.

Small Motors. (Internal Combustion Engines up to 100 H. P.).

Fundamentals of University Chemistry. By Wilh. Ostwald.

Concerning Distillation of Peat, and Conversion of Peat into Cash. By S. Jabs.

Pipe Lines. Published by the Association for High-Pressure Lines.

Determining the Equivalency of Varicolored Light Sources, by considering the brightness of the flame, Visibility and Flicker Photometry.

In the French Language.

Treatise of the Theory and Practice of Gas Manufacture, and its Various Applications. By E. Borias.

Proceedings of the 35th Annual Meeting of the Technical Association of the Gas Industry in France.

Production and Application of the Lean Gases.

In the Dutch and Italian Languages.

Handbook of the Duties and for the Guidance of Gas Fitters. By Kleyneberg, Harlem.

Official Technical and Commercial Directory of the Gas, Electric, Water and Telephone Business in Italy.

Joly's Technical Information and Directory for 1909.

II.

Classified List of Subjects of all Papers on Technical Matters Presented Before the Gas Associations of the World Since October, 1909.

Chemical matters	12
Illumination	12
Retort house practice	10
Water gas manufacture	8
High-pressure distribution	8
Photometry	7
Gas engines	7
Retorts and benches	5
Producer gas	5
Incandescent lighting	5
Tar (use on roads)	4
Calorimetry	3
Distance lighting	3
Meters	3
Purification	3
Gas street-lighting	3
Ammonia recovery	2
Coke	2
Distribution	2
Industrial gas	2
Manufacture of coal gas	2
Gas arc lamps	1
Coal	1
By-product coke ovens	1
Electrolysis	1

Fire-Brick	1
Gas holders	1
Protection of iron	1
Oils for gas making	1
Main laying	1
Producer gas plants	1
Sulphur determination	1
Total	119

III.

Classified List of Subjects of United States Patents Pertaining to the Gas Industry, Issued During the Year Ending September, 1909.

(Compiled by Frederic Egner).

Gas producers	51
Acetylene apparatus	41
Carburetters (including air-gas)	25
Vertical and inclined retort apparatus	10
Scrubbers	8
Water-gas apparatus	5
Purifiers	5
Gas holders	4
Valves	4
Oil gas	3
Wood gas	3
Limestone gas	3
Combination producer and water-gas	3
Hydrogen gas	3
Water seals and drips	3
Mixed coal and water-gas	2
Rotary retorts	2
Regenerative retort bench furnace	1
Tar gas	1
Liquid gas	1

Tar extractor	1
By-product recovery plant	1
High-pressure lighting and heating	1
Separating mixed gases	1
Governors	1
Condensers	1
Total	184

IV.

Classified List of Subjects of English Patents Pertaining to the Gas Industry Described in the "Journal of Gas Lighting" from Oct. 1, 1908, to Sept. 14, 1909.

Incandescent gas burners	64
Meters	31
Distance lighting	28
Fuel gas burners	26
Valves	22
Gas producers	18
Gas stoves	16
Treatment of gas	16
Processes of gas manufacture	13
Regulators and governors	13
Charging and drawing machinery	11
Gas holders	10
Mantles	10
Pipe laying	10
Gas engines	9
Gas exhausters	8
Retorts	7
Pressure gauges	5
Purifying apparatus	5
Water-gas apparatus	5
Manufacture of ammonium sulphate	4

Coke quenching and handling	3
By-product coke ovens	3
Fire-brick manufacture	3
Gas analysis	3
Pyrometers	3
Retort settings	3
Extraction of sulphur from oxide	3
Spraying tar on roads	2
Briquettes	1
Coal handling apparatus	1
Leakage indicators	1
Meter connections	1
Retort furnaces	1
Scrubbers	1
Distillation of tar	1
Total	361

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Coalite 275
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Producer gas power plants 260
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Reversing condensers 270
Sulphur purification 265
Technical education in gas engineering 261
Utilization of tar 263
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Water-gas apparatus 251

THE PRESIDENT: The paper that Mr. Butterworth has presented to you means a great deal of work, a great deal of painstaking work; I do not know that it calls for any discussion, but if any gentleman would like to ask any questions, no doubt Mr. Butterworth would be glad to answer them. If not, we will go forward with the program.

MR. EGNER: I think a paper such as Mr. Butterworth has just read should not go by without some comment. I have been sitting here closely watching to see if he missed anything. I think Mr. Butterworth has forgotten nothing. Therefore, I move a hearty vote of thanks for his excellent work in the preparation of this paper.

MR. GARTLEY: I second the motion.

The motion was carried by a rising vote.

THE PRESIDENT: The next item on our program is a lecture on "Illuminating Engineering," by Dr. Edw. P. Hyde. (Applause). It gives me great pleasure to introduce Dr. Hyde, whom I think all of you heard last year.

DR. HYDE: Mr. President and Gentlemen of the American Gas Institute, the paper to which I invite your attention this afternoon can scarcely lay claim to so comprehensive a title as that given in the program. The topic on which I have chosen to write is "The Relation of Natural Science to the Development of Lighting."

THE RELATION OF NATURAL SCIENCE TO THE DEVELOPMENT OF LIGHTING.

By Edw. P. Hyde, Director, Physical Laboratory, National Electric Lamp Association.

In the onward march of scientific and technical development and achievement it is expedient that we pause at intervals, and aided by memory and imagination, that we mount some commanding hill of contemplation. In retrospect we scrutinize the pathway of our progress, in prospect we scan the vast field of opportunity. We are encouraged by our accomplishments; we are spurred on by our possibilities; but what is more

important than either of these, we realize afresh that the present is not all, that, indeed it is but a pitched camp on the endless plains of time.

Let us stop for a while today in our mad, onward rush, to take our bearings. Would that it lay within my power to present to you a complete, accurate picture of the development of all phases of lighting, properly correlated, and to reveal to you a classified scheme of new opportunities. Unfortunately time and personal incompetency preclude the former, and natural limitations the latter. May we not, however, trace the development of lighting, as well as of every other industrial art, to an antecedent development of scientific knowledge, and thereby secure the key to both the accomplishments of the past and the possibilities of the future?

The art of lighting has followed in the wake of the achievements of science; the possibilities of lighting must depend upon the further development of science. I think we are all too prone to forget the debt which technical and industrial development owes to that oft-neglected and much discouraged science which constitutes the foundation for practical applications, and without which the innumerable comforts and conveniences of modern life would be impossible.

The interdependence of scientific conception and industrial application is so patent, even to the most casual observer that it would be presumptuous to undertake to demonstrate the intimate relationship existing between these two branches of human knowledge and human achievement. And yet, I fear, even the most thoughtful are apt at times to acquire a somewhat distorted perspective. We have but to turn the pages of history to convince ourselves of the truth of the proposition, "Every industrial achievement is traceable to some antecedent discovery of natural science." And I am inclined to think that the more careful student of the history of natural science and the industrial arts will at the same time be convinced of the truth of the converse of this proposition, viz.,—"Every discovery of natural science conduces to some subsequent indus-

trial application." The direct proposition gives the key-note to the developments of the past; the converse proposition gives the key-note to the possibilities of the future.

The cycle of the conception and application of scientific truth is of variable duration. In one epoch an hypothesis is conceived, or a new phenomenon discovered; in another it receives experimental confirmation and is correlated with the rest of classified knowledge; in another it is applied to meet some human need, or to satisfy some human desire; and then we all forget its origin in the close familiarity of everyday life with it. This entire cycle may take place within the brief period of a single human life, or it may extend over centuries. The important fact to be remembered is, that every achievement of scientific investigation will complete its cycle at some time.

Illustrations crowd upon us in every domain of applied science. Indeed the very term "applied science" records indelibly the scientific origin of those applications which have made their advent so recently that their parentage has not yet been forgotten. Messages transmitted through the medium of electric waves we call "Marconigrams," but do we forget that without the theory of the physicists Faraday and Maxwell, and the brilliant experiments of the physicist Heinrich Hertz there would be no wireless telegraphy today? As a still more familiar illustration it is only necessary to consider the navigation of the seas, which wireless telegraphy is now robbing of many of its perils, to be reminded of the scientific origin of the most commonplace achievements of our civilization. The mariner's compass and the science of the heavens are the pre-requisite conditions of every trans-oceanic passage, but few of us picture the unappreciated scientist pursuing in his isolation the investigations which have brought happiness and wealth to thousands of his posterity.

In these homely illustrations one man has conceived, another has applied, and humanity has reaped the benefit. It sometimes happens that scientific ability and practical genius

are united in a single individual. One of these rare examples is to be found in the late, deeply lamented, Lord Kelvin, whose pioneer work on the trans-Atlantic cable stands out uniquely as the accomplishment of the happy combination of pure science and engineering application.

In our present highly complex and completely differentiated civilization the combination of scientific imagination and engineering accomplishment in a single individual is rare, and quite likely, I think, to become obsolete. On the other hand, the relation between the physicist and the engineer is daily growing closer. The discoveries of science are more eagerly grasped at, and more quickly applied. The differentiation of functions is accompanied with an integration of results. This is the only proper organization, and to those far-sighted men who appreciate the interdependence of theory and practice, in whatever branch of human activity they may be engaged, will ultimately come the fullest measure of genuine success.

Let us consider briefly some of the scientific problems with which we are confronted at present. The first pre-requisite to an exact and fruitful science is an exact system of nomenclature and standards. We have just emerged from a successful campaign for a common national and international unit of luminous intensity. We should just be entering upon a longer and perhaps more trying campaign in behalf of a more suitable and universal system of nomenclature, definitions and units. We should, if possible, have a universally accepted primary standard of light worthy of the name; and I am confident that if an adequate standard is developed, it will sooner or later receive international sanction. The adoption of a common international unit was the first necessary step, but we should not stop here. Let us press onward to a common, scientifically accurate standard of light which may serve as the reproducible custodian of our common unit.

We are in dire need of a universal adequate nomenclature as attested by the confusion and difference of opinion which prevail. Shall we call the unit of luminous intensity the

"candle," or shall we break with the past and in adopting the new unit call it the "pyr," or the "phos," or some other of the various names proposed by Blondel and others? At both of the last two conventions of the American Gas Institute I had the great privilege and pleasure of attending your sessions, and of addressing you as an exponent of the common national and international candle. Today I have no case to present, no particular cause to plead, I have only to report to this Institute what, as a casual observer on the hill of contemplation, I see on the horizon. And one thing that I think I see clearly is the need for a more universal, more adequate system of nomenclature and definitions.

It seems to me that we should sit down calmly and deliberately and give our best efforts in conjunction with others of this country and abroad, to the consideration of these questions, and that we should not be contented until we have agreed upon a scheme which is theoretically correct and practically applicable and convenient. The importance and value of the work of your committees on "Methods of Taking Candle-power of Gas," on "Calorimetry," and on "The International Unit of Candle-power" cannot be overestimated. We need more work of this kind, carried out with the same thoroughness and definiteness of result.

As an illustration of some of the advantages to be gained by adopting and practicing a more modern system of nomenclature, I would bring to your attention once again the idea of "light flux." It might be objected by some one that this idea of "light flux" should scarcely be adduced in illustration of very modern innovations, since it was suggested some fifteen years ago by Blondel. In reply to such an objection I would ask, how many of you are using "light flux" in your daily practice? Indeed, judging from current publications in the technical press of this country it would seem that to many not only the application, but the very conception of the idea of "flux of light" is startlingly new and original, owing probably to a lack of appreciation of its practical utility.

With Blondel I would be inclined to base my system on the idea of flux as the foundation, although I should prefer to modify slightly the prevailing definition of the term. As ordinarily defined, flux is intimately associated with a solid angle. Since a solid angle has significance only in the case of point sources, and in order, moreover, to bring our photometric nomenclature into accord with those of analogous sciences, I found it very convenient, several years ago, in studying the mathematical theory of radiating surfaces[1] to consider *flux* as a point function in space. Without stopping now to elaborate the idea which is discussed at some length in the article to which reference is given, it is sufficient to say that I defined the *specific luminous flux* (or perhaps better, the *intensity of flux,* or even simply the *flux*) at any point in space, and in any given direction, as the rate of flow of luminous energy across a unit area normal to the given direction at the given point. The total flux from any point or extended source or group of sources is then the integral of this point function taken over a closed surface enclosing the source or sources.

Whatever should ultimately be adopted, let us approach the matter with no unalterable bias of false precedent or short-sighted commercialism. It is my observation that whatever is right, based on sound principles, will ultimately prevail, and bring with it commercial success, no matter how difficult the transition from the old to the new may have seemed.

In this connection I want to ask your most careful consideration of the claims of the metric system. In the reconsideration of the nomenclature and units of photometry we shall come face to face with the question of the adoption of the metric system. What shall we do with it? I personally believe that there is little doubt but that ultimately the metric system will prevail universally. What shall we do with it now? Shall we take the lead and urge the adoption of a unit of illumination which shall be expressed in centimeters

[1] Hyde—"Geometrical Theory of Radiating Surfaces, with Discussion of Light Tubes." Bureau of Standards Bulletin, Vol. 3, No. 1, 1907; p. 81.

and not in feet, or shall we still insist upon the "foot-candle?" Even in England, the birthplace of the British system, there is a strong feeling in favor of the more scientific definition,—more scientific because the metric system is the alphabet of natural science in all civilized countries. Whatever may be the outcome, let us not shrink from the important task, arduous as it may be, of undertaking honestly and seriously, in co-operation with other interested bodies, the reconstruction of our system of nomenclature and units.

Although an exact system of nomenclature and standards is a pre-requisite to an exact and fruitful science, we should remember that it is only a necessary preliminary. Names and units have value only as affording means of recording and transmitting from one to another the accomplishments of scientific thought and investigation. It is to the science itself, rather than the language of science, to which I would especially ask your attention today. What are the vital scientific problems in connection with lighting which confront us at the present time?

These problems may be divided into three classes:

(1). Those which have to do with the production of light.
(2). Those which have to do with the utilization of light.
(3). Those which have to do with the effects of light.

Under the first head would come the study of the laws of radiation and of the radiating properties of matter; under the second the study of the reflecting, absorbing and diffusing properties of matter: and under the third the study of the action of light on the eye, on the skin, and on microscopic organisms.

Although much progress has been made, particularly in recent years, in our knowledge of the laws of radiation and of the radiating properties of matter, the doors to this field are still wide open. We have but to recall that even in the electric arc, one of the most efficient light producers in use, less than one-half the energy is available for light. Practically all of the rest of the energy is radiated in the form of heat,

in wave-lengths too long to affect the human eye. What would we think of a motor or any other transformer of energy that had an efficiency under 50 per cent.? And yet the low efficiency of luminous sources persists despite the constant efforts that are being put forth to improve it. The problem is still open for solution, and as in the past, so in the future the solution will probably come gradually; but whereas in the past much of the progress has been made, in the words of Carl Zeiss, through the "bog of haphazard experiment," we are to look for progress in the future as a result of careful scientific investigation of the radiating properties of matter.

We realize now that it is much better to utilize all the energy of illuminating gas in complete combustion, and to obtain the light from a mantle of rare earths heated to incandescence, than it is to depend for our light on the glowing particles of carbon in the open flame. This higher efficiency of the mantle is probably due, to a considerable extent, to the peculiar radiating properties of thoria and ceria. But do we know the complete physics of the incandescent mantle? I take it that we do not, and I firmly believe that the most important step toward the improvement of the efficiency of incandescent mantles is a thorough understanding of their properties as they exist now. Knowledge is power; perfect knowledge of things as they are is a most important guide to things as they may become.

Added to our knowledge of the production of light it is necessary that we know how to utilize economically and effectively the light we can produce. First we must be able to measure accurately and practically the light that is available. This is photometry in its broadest sense, involving the sensibility of the eye to light of different wave-lengths, and those manifold complications which arise when we attempt to compare lights of different spectral composition under the varying conditions met in practice. Secondly, we must study the absorbing properties of glass and other globes and reflectors, the reflecting and diffusing properties of those ma-

terials which enter into the decorations of our shops and houses, and with these the general fundamental physical laws which underlie the more familiar phenomena.

The whole object of our enterprise is to produce light, a sensation and therefore a phenomenon which depends on the presence of an observer. We desire light because we want to see, and it is impossible to see without light. All our efforts are concentrated in rendering possible to mankind the convenience and comfort and pleasure of seeing at times, and in places where the natural light of day does not penetrate. Do we fully appreciate how vital it is that we exert every precaution possible to protect our eyes against the possible ravages of inadequate or harmful natural and artificial illumination? Ophthalmologists tell us that many of our eye troubles are to be ascribed to defective lighting, and yet how little do we know about the real defects of our lighting systems. Our knowledge is so meager and inexact on this, one of the most vital and important questions of the day, that we should be very careful indeed in our eagerness to learn, that we do not accept indiscriminately all we see written on the subject. Due to the very limitations of our knowledge it is difficult to refute positive statements from others, no matter how sure we may feel inwardly that the statement has no true scientific foundation. It is very easy to make positive statements; my observation is that it is very difficult to demonstrate conclusively the simplest ones.

I think I am correct in stating that at present it is not known exactly to what extent eye injury may arise from degrees of intensity or to what extend to spectral composition. Dr. Schanz, an oculist, and Dr. Stockhausen, an engineer in Germany, have concluded that ultra-violet light in such quantities as it is found in many artificial sources is positively harmful, and should be eliminated. To this end they have introduced "Euphos" glass which, it is claimed, will absorb most of the harmful rays. The presentation of this work before scientific and technical bodies has called forth a storm of protest. In particular, Dr. Voege, of the Staatslaboratorium

of Hamburg has published the results of numerous experiments to show that in daylight illumination under comparable conditions there is more ultra-violet light than in those artificial sources which were found harmful by Drs. Schanz and Stockhausen.

What conclusion, if any, shall we draw? I recently had the great pleasure of visiting the laboratory of Drs. Schanz and Stockhausen, and of witnessing some of their simpler experiments. Their work is most interesting and suggestive. I also had the pleasure of talking with Dr. Voege and of reading his papers. His physical work seems to have been carefully done. It would seem, therefore, that there is need for a repetition of the work by the same and also by other observers, giving great care to the conditions of the experiments. The work is difficult and needs encouragement; it is most important, and needs support; and by whomever undertaken, let us insist that no short-sighted commercialism shall distort our perspective. The matter is all too serious to brook any misrepresentation of facts.

In England a commission has recently been appointed with Prof. Crookes as physicist and Dr. Parsons as ophthalmologist, to investigate the cause of cataract in the eyes of certain glass-workers. Whether the serious eye-malady is to be ascribed to the harmful effect of certain light on the eye, is not yet determined; but whatever the decision of the commission, it is indicative that the nations are arising to protect as far as possible the most delicate sense organ of man from unnecessary injury.

Although this is perhaps the most immediate effect of light to be investigated, there are other effects that will deserve our careful attention. Some few scattered experiments have been conducted to show the effect of light on germs. What a boon to humanity it would be if we should find it possible to arrest or check the spread of contagious disease or to revitalize the blood of anemics by the simple application of day or suitable lamp light! I have no particular hope to hold out

in these respects, but I do state that the experimental investigations in this not unpromising field are wanting.

In this brief survey with untrained and hazy vision from the hill of contemplation, I have no doubt failed to see many things which stand out sharply on the horizon of others. Other problems, other needs, other obstacles and opportunities present themselves. Let us ever be mindful, however, that the technical and industrial developments of the future rest on the scientific accomplishments of the past and present. Let us, therefore, contribute our share to the present development of science, since it is not our privilege to repay the science of the past for the industrial applications of which we are reaping the harvest today.

In this connection I would like to bring to your attention very briefly the work of the Physical Laboratory of the National Electric Lamp Association, with the organization and direction of which I have been intrusted. It has been called the Physical Laboratory in order to distinguish it from Chemical and other Research Laboratories which have for their purpose the immediate development of some commercial product. In outlining to you today the scientific problems with which we who are interested in lighting are confronted, I have described to you in the clearest and simplest way the object and purpose of the new Physical Laboratory of the National Electric Lamp Association. Its object is scientific; its personnel consists of several trained physicists and a trained physiologist, together with the necessary clerical and mechanical assistants; its organization is three-fold, the divisions covering approximately the three classes of problems which I have outlined; and finally its purpose is to add whatever little it may toward the development of the science and the solution of the scientific problems with which we are confronted. I invite you all to visit us in Cleveland, Ohio; I ask your sympathy and co-operation; and I would welcome any suggestions which may conduce to the better development of the science, and ultimately, therefore, to the good of mankind.

THE PRESIDENT: Are there any remarks anyone cares to offer on the subject? On the program we have put this lecture adjoining the paper by Mr. Macbeth, thinking that perhaps they might be considered together and discussed at the same time. If there is no objection, we will proceed now with Mr. Macbeth's paper.

Mr. Norman Macbeth then read his paper on ILLUMINATING ENGINEERING IN ITS PRACTICAL APPLICATIONS. This paper was accompanied by numerous stereopticon slides.

PRACTICAL APPLICATIONS OF ILLUMINATING ENGINEERING.

In one of the recent numbers of the technical press, the statement is made "that electricity had gotten such a good start and prospered until to-day it is nip and tuck for business between gas and electricity.....The lighting and small power business is going the electric way in bounds and that gas for lighting will be discredited everywhere unless something is done to give the people something better for a less price."

The explanation is offered that the average gas man is lazy and a plea is made for contributions from gas men and their new business managers who, because of their success, cannot be included in the above indictment.

"We want a new era in gas lighting rather than a pushing of old methods. We need art glassware, well designed attractive fixtures, new lighting effects, new talking points, a little engineering, something from the decorator, a word from the oculist, substantial construction, convenient devices, and a system of maintenance that will keep the lamps always looking like new. Experts in lighting must be developed and there is no time like the present to begin."

Looking at the above statements broadly, we are forced to admit that they are true. From a somewhat inside knowledge of the situation, however, the writer is of the opinion that while undoubtedly the average gas man has not made the most of his opportunities, nor taken advantage of all

the openings afforded him, he is not lazy, but badly handicapped for necessary information which would have a direct bearing on his sales.

The situation is largely one of salesmanship. Salesmanship alone, however, would not go very far unless backed with appliances and service, which are all that they should be, or at least as represented. Thorough maintenance is necessary, attractive and artistic glassware and fixtures desirable, and a proper treatment of the installation, from the standpoint of effective illumination, absolutely essential.

Regarding the "something better for a less price" statement, the writer is of the opinion that the "something better" is of vastly more importance than the lesser price. The best, however, is in the end always the least expensive. "Satisfactory service" carries and commands a high capitalization Top notch maintenance at a dollar is more acceptable to the consumer than poor, indifferent service at a quarter of that cost. A good lamp or mantle is better than a poor one, and is always worth the additional cost. Cheap, unsatisfactory mantles and equipment have done their full share to depreciate gas illumination. To the consumer and to many gas men, mantles and lamps differ only in price.

A Standardizing Committee of this Association, acting with the manufacturers of gas lighting accessories, would seem to be a necessity. Mantles can then be required to meet specifications, which have been determined by thorough test to be satisfactory—standardized for size, color, cerium and thorium content, strength, weight and other points of importance. Mantles which show a depreciation of 10% in 1000 hours are certainly entitled to a different classification than that kind which will show a drop of 10% in 250 hours, and as much as 30%, or in lower grades, 60% in 1000 hours.

Burners can be chosen with a view for the purposes and locations in which they will be used; their characteristics under various pressures and with different kinds of gas, can be investigated and the results published. A burner showing

phenomenal results at one particular pressure on a laboratory test, may be a burner which would be of little practical value when used under the variable pressure conditions of the many towns and cities throughout this country.

A tabulation from Brown's 1908 Directory gives on 825 Companies, as follows:

146 or 17.6% reporting between 1 and 2 inches pressure.
521 or 63 % reporting between 2 and 3 inches pressure.
158 or 19.2% reporting between 3 and 6 inches pressure.

It is not believed that these figures are accurate. They should, however, represent at least a shrewd guess or express the preference of the distribution engineers of the plants indexed. Low pressure in certain localities is a condition quite general; experience would tend to show that the maximum pressures are rather higher than shown by the above table.

Reference to the diagrams Fig. 1, may give an idea of this effect of pressure, which shows widely different results with different burners. Curves Nos. 1 to 5 are upright lamps, and Nos. 6 and 7, inverted. Nos. 1, 2, 3, 4 and 6 were plotted from results of tests on single burners, by L. W. Wild.[1] Nos. 5 and 7 are American Lamps, upright and inverted, respectively, and show a marked difference in performance. The values in Nos. 1 to 6 show the efficiency of duty of these burners in terms of horizontal candle-power per cubic foot; those in No. 7 are in terms of mean spherical candle-power per cubic foot of gas at pressures from 1.6 inches to 6 inches of water. This curve shows characteristics of extreme value; at all pressures beyond 2 inches, it will be noted the efficiency shows a slight increase throughout. No. 6 shows the point of maximum efficiency at about 1.5 inches. For use exclusively in very low pressure, No. 6 would undoubtedly be the better lamp; beyond 2 inches, however, this lamp would give very poor results. Curve No. 5, while not ideal by any means, is in marked contrast to Nos. 1 to 4. In the later tests the lamps were adjusted for maximum intensity at each .4

[1] Journal of Gas Lighting, Vol. 48, 1907, p. 24.

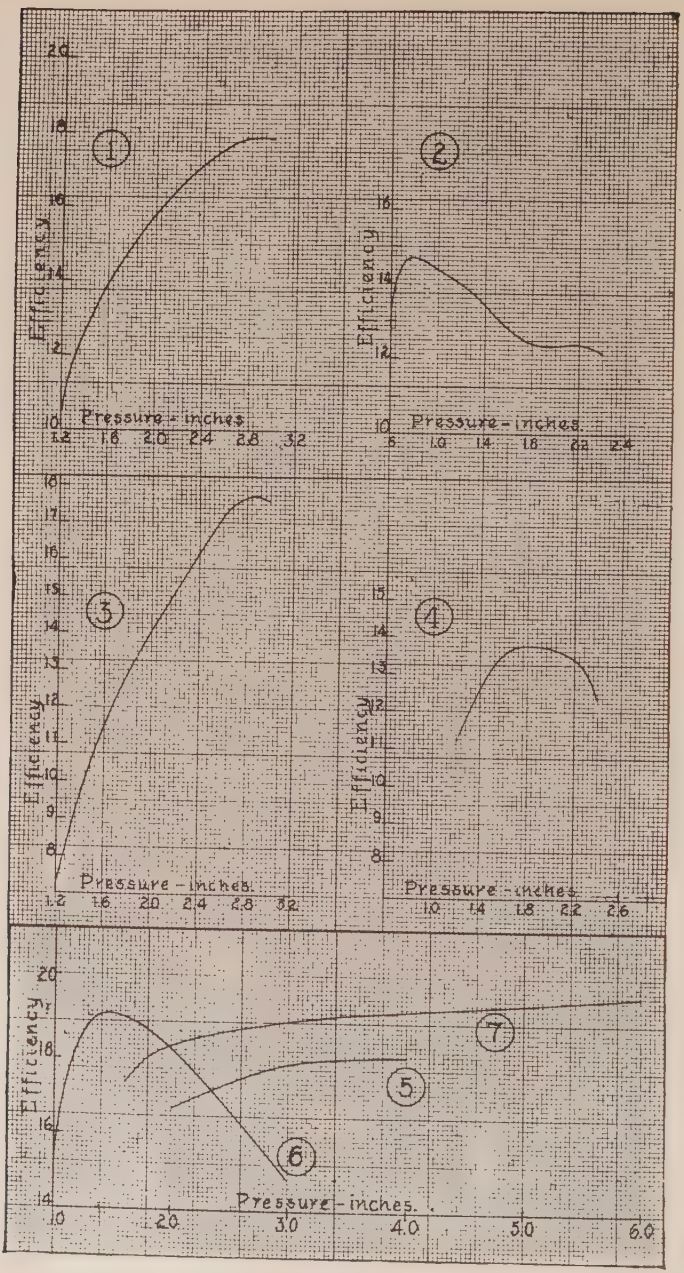

Fig. 1.

inch change in pressure. Lamp No. 3 shows a duty at 1.3 inches but 50% of that at 2.8 inches.

In fact, any of the lamps represented by 1, 2, 3, 4 and 6 would show considerable differences in light output with changes in pressure. The ideal lamp would be that in which the efficiency curve would be shown by a straight line.

If these curves of the lamps investigated to 3 inch pressure only, are representative of average performance, the majority of them have little to recommend them to users requiring illumination, and would be expensive at any price above that commanded by their weight in scrap metal.

In the determination of factors for use in designing lighting installations, conditions similar to the above must be taken into account, and until such times as authorities can succeed in a standardization of mantles and lamps, any factors given must necessarily be true for that particular manufacturer's product only, although in a general way they may be applied to other lamps having somewhat similar characteristics and efficiencies.

The tables here given may for these reasons be somewhat restricted in their use. As they are typical, however, of an output of many thousand lamps, it was thought advisable to publish them in this manner with the qualifications as given above.

The factors given in Table No. 2 are taken from observations physical and illuminometer measurements made on actual installations with average quality gas and with pressures of 2 and 3 inches, and represent results of investigations, which have been under way for over a year, both in the laboratory and on existing commercial installations. These installations were generally subject to maintenance service and no attempt was made to secure the highest efficiencies, but rather representative working conditions, which could be readily duplicated.

It might be well at this time to give concise definitions of three of the terms in general use by illuminating engineers.

The unit of light intensity is the candle-power.

The unit of illumination—the foot-candle.

And the unit of light flux or quantity—the lumen.

The unit of candle-power is reproduced from specifications or by comparison with the standards maintained at the National Bureau of Standards at Washington, D. C. A mere statement of the candle-power of a source does not mean anything unless qualified by a statement of direction, or mean candle-power in a sphere or definite part of a sphere nor should candle-power be conceived to represent a quantity of light or associated, in any way, with distance.

The foot-candle is that illumination produced by a standard candle on a point surface at 1 foot distance, and it is this illumination which is effected by the distance from the source, the intensity of illumination varying inversely as the square of the distance. Thus, at 4 feet distance from a 16 candle-power lamp in the direction in which we get 16 candle-power, the illumination would be 1 foot-candle, and 2 feet distant it would be 4 foot-candles, as the relative size of the surfaces, over which the same quantity of light is effective, are as 4 to 1.

The lumen is that quantity or flux of light which will produce a normal illumination of 1 foot-candle over a surface of 1 square foot.

A spherical candle produces 12.257 lumens.

TABLE NO. I.

Class of service.	Illumination in foot-candles
1. Store-rooms, warehouses, etc...	.5 to 1.5
2. Residence and reading rooms ..	1 to 3
3. General stores	1 to 3
4. Dry goods stores	4 to 7
5. Clothing stores	4 to 7
6. Detail work tables	5 to 15
7. Show windows	10 to 50

TABLE NO. II.

Lighting Unit	Nominal consumption of unit cu. ft.	Factors. Lumens per cu. ft. of gas per hour Light ceiling	
		With light walls	with dark walls
Reflex lamps with frosted tip cylinders, Welsbach-holophane or light (imported) opal concentrating reflectors....	3⅓	125	114
Reflex lamps with frosted tip cylinders, Welsbach-holophane or light (imported) opal distributing reflectors....	3⅓	110	100
Reflex lamps with frosted tip cylinders, French roughed ball globe.....	3⅓	95	70
Reflex cluster lamp, 4-mantle, with alabaster globe	13	85	64
Inverted 5-mantle arc with alabaster globe	16.6	87	65
Upright 4-mantle arc with opal reflector and alabaster globe	20	75	55
Upright 4-mantle arc with alabaster globe only	20	66	48

Spacing Rules.

In large rooms, Reflex lamps with reflectors on single or multiple fixtures should be suspended 7 to 17 feet above the plane or approximately 9 to 18 feet above the floor, with the distances between outlets not exceeding 1⅔ times the height of the lamps (to mantle centres) *above the plane.* With roughed balls the distance should not exceed twice the height. In rooms with low ceilings, single lamp units may be required with proportionate distances apart, as given above.

Inverted cluster and inverted arc lamps should be suspended not lower than 7 feet above the plane, and with the distances between outlets not exceeding 2 times the height *above the plane.*

Upright mantle arc lamps not lower than 6 feet above the plane or 7 to 9 feet above the floor, with distances between outlets not exceeding 3 times the height *above the plane.*

The *"Plane"* is the surface assumed, ordinarily 2 feet 6 inches above the floor, on which the illumination is required.

In using these tables, reference should be made (first) to Table No. 1 to determine the intensity of illumination desired, and (second) to Table No. 2 for the factor from which is secured the cubic feet of gas and number of units required to secure this intensity with the equipment selected.

Rule: Cubic feet of gas per hour, equals, area in square feet, multiplied by the foot-candles required (Table No. 1), and divided by the factor, "lumens per cubic foot" (Table No. 2).

The cubic feet of gas per hour divided by "the nominal consumption per light unit" gives the number of lamps or light units required.

The above tables, supplemented by experience in placing lamps, will give results more satisfactory than can be secured through any method at all approaching this in directness, and with a minimum expenditure of effort.

The most satisfactory way to solve an illumination problem is to work from a plan of the room or area to be considered. This area may be divided into bays or sections of regular or irregular size, as may be necessary, and any special section can then be given an individual treatment, increased or reduced intensities, according to the character of the goods displayed or the purpose for which the illumination is desired. The proper placing of the units thus decided upon is largely a matter of experience and judgment.

The proper height at which to hang lamps and fixtures should be largely governed by the requirements of the room under consideration. Inverted mantle units especially should be placed as high as possible in order to take advantage of the favorable light distribution of this source, also to protect the eye against glare and the unsatisfactory effects so prevalent

with upright mantle sources, which, because of their distribution characteristics, were suspended much too low for effective illumination.

In Fig. 2 is shown the similarity of light distribution from two upright mantle sources, on the right an upright mantle arc with opal reflector, and on the left an upright lamp with Q chimney. The distribution of the upright arc without reflector, is quite similar to this curve on the left, the apparent

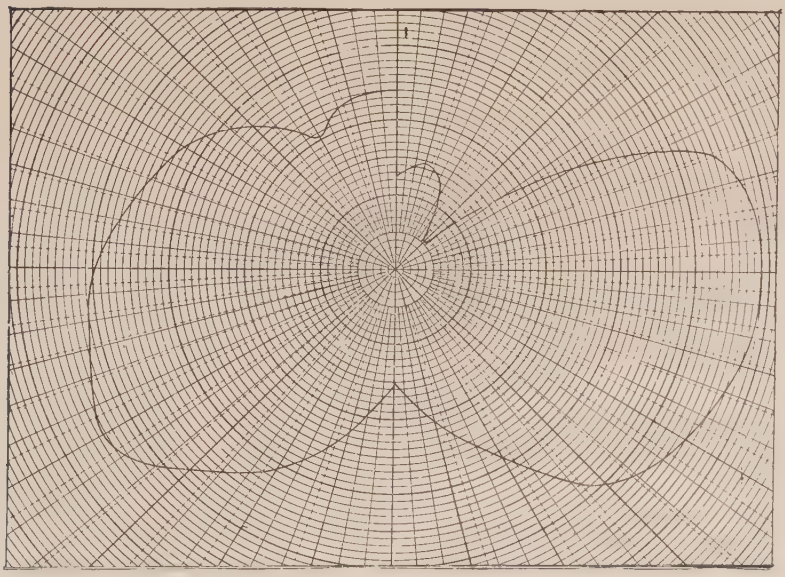

Fig. 2.

candle-power values of which were here changed 1 to 4, to enable the comparison to be more readily made. These lamps were usually hung quite low.

Fig. 3 shows a cross section elevation of a room 14 feet high and 14 feet wide with the "Plane of Illumination" 2 feet above the floor. For a source suspended 6 feet above the plane (8 feet above the floor) the proportionate intensities are shown on the left for uniform normal illumination on the plane—walls,

and ceiling. On the right are shown corresponding values for a source 10 feet above the plane.

The intensity on the walls may and should be less than that in the central portion of the room. We desire only sufficient light to illuminate the wall fixtures or shelving, and this may

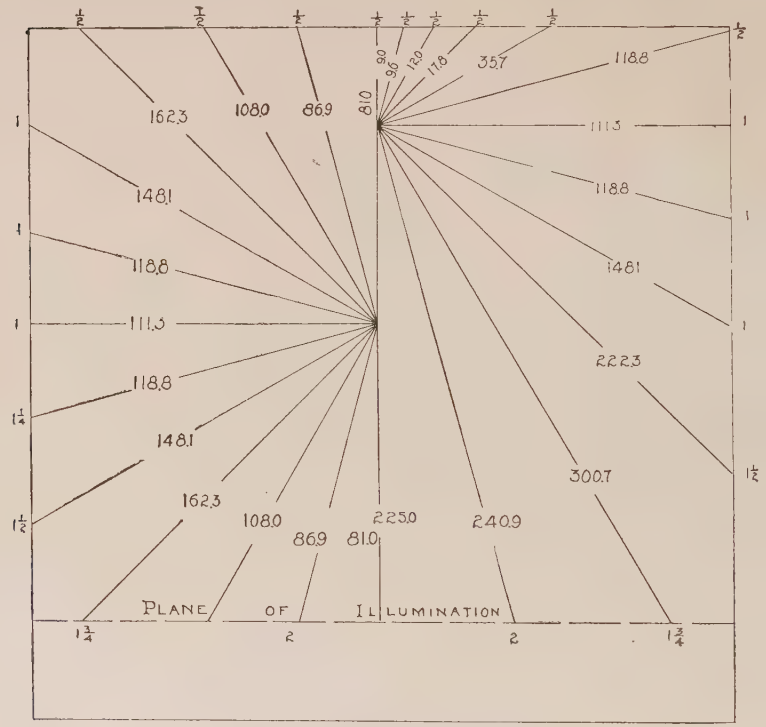

Fig. 3.

properly be one-quarter of the maximum on the plane. A brightly illuminated wall, through its effect on the eye, necessitates a higher intensity throughout the room where the light is required for close discernment of objects or goods, thereby reducing the efficiency of the installation as a whole. Therefore, assuming that a uniform intensity of illumination on the plane, walls and ceiling, is not desirable, the proportions were modified as shown by the marginal notations, Fig. 3, *i.e.*, two parts on the plane to one-half on the ceiling and one on the upper side walls.

The solid line curves, Fig. 4, show this relation. The dotted curve on the left is the distribution curve of an upright arc, that on the right, of an inverted mantle source equipped with prismatic reflectors. A comparison of these curves gives a fair

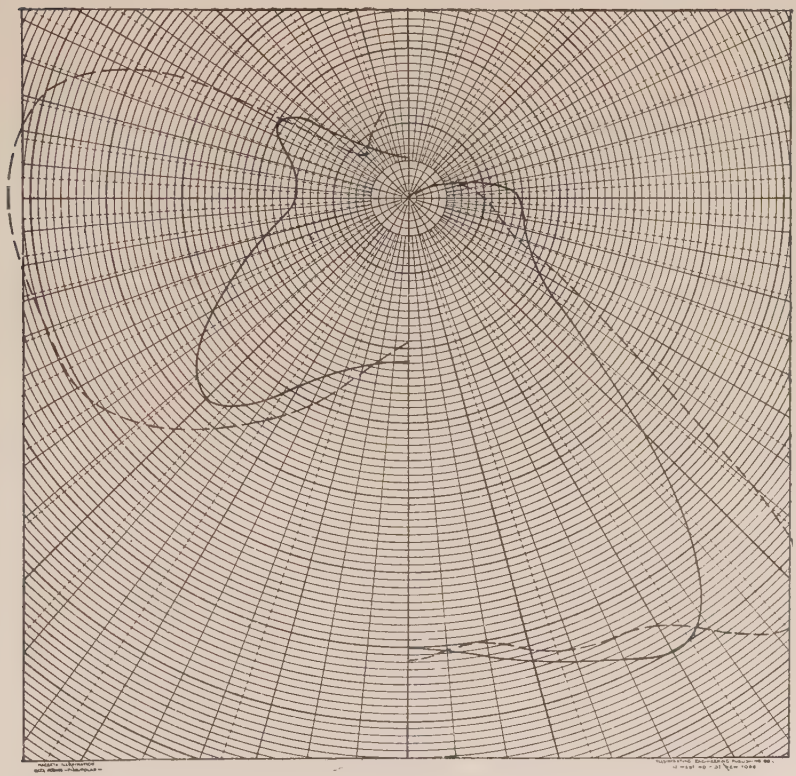

Fig. 4.

idea of the distribution efficiencies of the two sources. The enormous amount of light in excess of that required, in the zone 30° above and 30° below the horizontal, which is dependent upon the low coefficient of reflection of walls, or shelving on which dark goods may be displayed, would ensure only a small percentage of this light ever reaching the working plane, and accounts in a large measure for the increased efficiency

of the more modern inverted lamp equipment over that of the upright.

It should be noted that by suspending the inverted mantle source higher than the upright, the intensities on the walls and ceiling will be sufficient and in proper proportion to that on the plane.

Believing that an application of the rules and tables here

Fig. 5.

given, to existing commercial installations would result in a better understanding of their use, the following photographs

and plans were prepared and will be analyzed in such a manner as it is hoped will bring out their good and bad points, and thereby serve as examples when making installations of a similar character.

In Fig. 5 is shown a millinery store, 79 feet 2 inches long by 14 feet 2 inches wide, with a ceiling 12 feet high. This store is lighted with 4 Reflex cluster lamps installed on outlets approximately 20 feet apart. The ceiling and upper side wall being light buff, with the lower side walls a dark green, considering in addition the wall cases and dark mission oak furniture, this installation would be considered under the heading of light ceiling and dark walls.

Referring to Table No. 2, we find this type of equipment will deliver on the effective plane 64 lumens per cubic foot of gas per hour. The area being 1121 square feet, the nominal consumption of gas on four outlets, 52 cubic feet per hour, the lumens per square foot, that is, the foot-candles effective per square foot, would be 52 times 64, divided by 1121, equaling 2.96 foot-candles. This intensity, when judged by the eye, was found to be quite satisfactory. The installation could, of course, be slightly improved by raising the fixtures. These are at present at a height of 8 feet 8 inches from the floor, which is considerably less than half the distance between the outlets.

In Fig. 6 is shown a somewhat unique installation, inasmuch as the ceiling is rather lower than the average, being but 9 feet 1 inch high. The area of this room (17 feet 2 inches by 38 feet 6 inches) is 661 square feet; light green ceiling, buff walls, green carpet. Considering the width of this room and the general arrangement of the counter and tables, together with the light ceiling and walls, the illumination can be handled very satisfactorily from the central outlets, using the fixtures as shown in the photograph.

The distribution of this particular lamp is shown in Fig. 7. This distribution, as may be noted, is quite wide, and with the

lamps placed close to the ceiling gives a very satisfactory effect. The lamps on the two fixtures on the beams are quite close to the beam, the ports being but 9 inches below. It might be mentioned in passing, that while this installation has been in use practically one year, on the Boardwalk at Atlantic City,

Fig. 6.

the air is clean and free from dust, and as a consequence, there has been no discoloration on the ceiling.

Referring again to the Table No. 2, under Reflex lamps with French roughed ball globe, we get a factor at 95 lumens per cubic foot of gas per hour. This factor, times the total consumption for the 9 lamps (30 cubic feet of gas per hour) divided by the area, 661 square feet, shows an effective illumination of 4.3 foot-candles. This would come under the head

of brilliant illumination; and as this particular floor is used

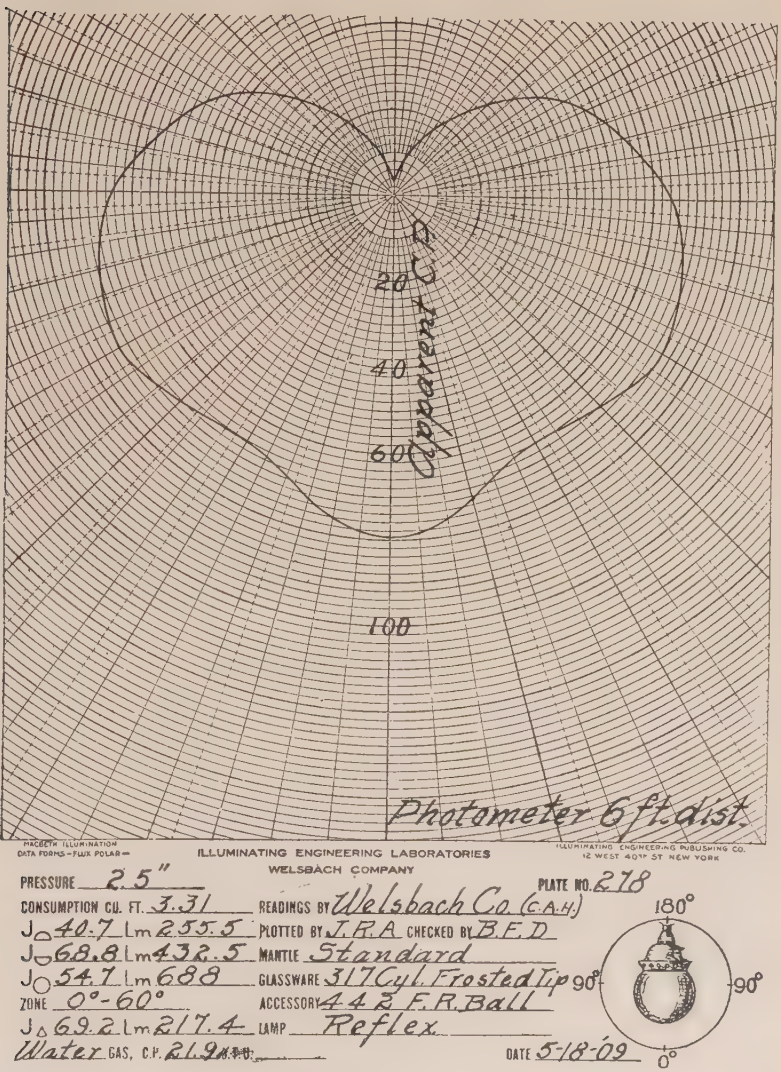

Fig. 7.

more as an advertising and display room, the resultant illumination is all that could be desired.

In Fig. 8 is shown another installation quite similar to Fig. 7, that is, so far as the purposes for which this store is used, and the type of light unit installed. This store is 18

Fig. 8.

feet 8 inches by 45 feet, with the ceiling 12 feet 6 inches high. The width between cases is 11 feet 8 inches, the cases being 7 feet 3 inches high, finished in white enamel paint. The ceiling and upper side walls are buff.

The outlets on this floor are placed approximately 9 feet apart, and for this type of distribution and outlet spacing, the fixtures are at about the right height, being approximately 8 feet from the floor to the centre of mantles. The cases being separately lighted, the effective area to be considered for the general illumination would be that between the cases, approximately 525 square feet.

With 5 four-light fixtures, having a consumption of 13 cubic feet each, or a total consumption of 65 cubic feet per hour, we would have 65 times 95, divided by 525, or 11.76 foot-candles. This, as may be noted, is extremely high, and has

been amply proven by experience to be twice the amount either necessary or desirable, the manager of this store stating that they did not at any time use more than two lamps to the fixture, finding that quite sufficient and resulting in very brilliant results being secured.

Considering Fig. 8 as an installation problem, with a length of 45 feet and a width between cases of 11 feet 8 inches, very good results could have been secured by using three outlets only, these outlets being spaced 7½ feet from each end and 15 feet between the end and centre outlets.

Using the same lamp equipment with a factor of 95 lumens per cubic foot, assuming an intensity of 5 foot-candles, 525 square feet multiplied by 5 (foot-candles intensity desired) equals total lumens, 2625. Total lumens divided by 95 (factor, lumens per cubic foot) equals cubic feet of gas per hour; and this divided by 3⅓ gives 8.3 lamps, or in round numbers 9 lamps. Having before decided upon three outlets, this fixes the arrangement at 3 lamps per outlet. The changed distance to 15 feet would warrant a change in height of lamps to 7½ feet above the plane or 10 feet above the floor.

It is evident that the installation here shown exceeded that required for a very brilliant effect by approximately 67%. It is on installations similar to Fig. 8 that electric salesmen find little difficulty in meeting gas competition.

In Fig. No. 9A, is shown the plan of a man's furnishing store. This store is 89 feet deep by 14 feet 6 inches wide, with a ceiling 15 feet 9½ inches high. The decorations would generally be classed as light. Wall cases 7 feet 11 inches high by 2 feet deep reduce the effective area to approximately 1290 square feet. There are installed 6 three-light fixtures with inverted lamps and Welsbach-holophane distributing reflectors, suspended at a height of 9 feet 8 inches from the floor to the center of mantles, at outlets approximately 15 feet apart. The total consumption is 60 cubic feet of gas per hour, or .0597 cubic feet of gas per effective square foot of floor surface, not including the wall cases.

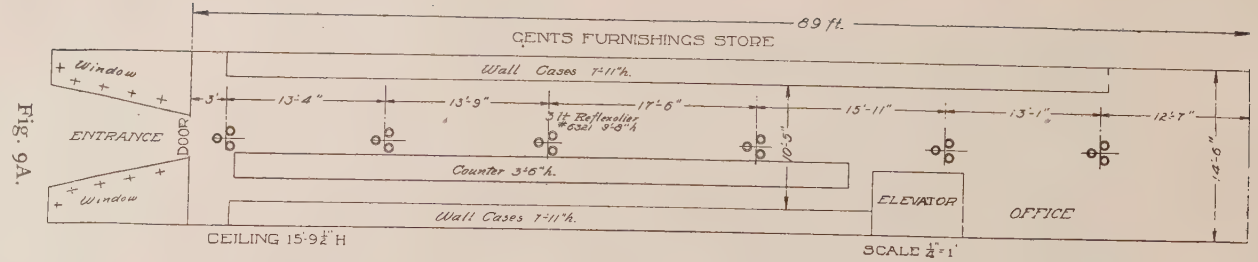
89 ft.
GENTS FURNISHINGS STORE
Window
Wall Cases 7'-11"h.
3'
13'-4"
13'-9"
17'-6"
15'-11"
13'-1"
12'-7"
3 lt. Reflexolier #6321 9'-8"h
ENTRANCE
DOOR
Counter 3'-6"h.
ELEVATOR
OFFICE
Window
Wall Cases 7'-11"h.
CEILING 15'-9½" H
SCALE ½"=1'

Fig. 9A.

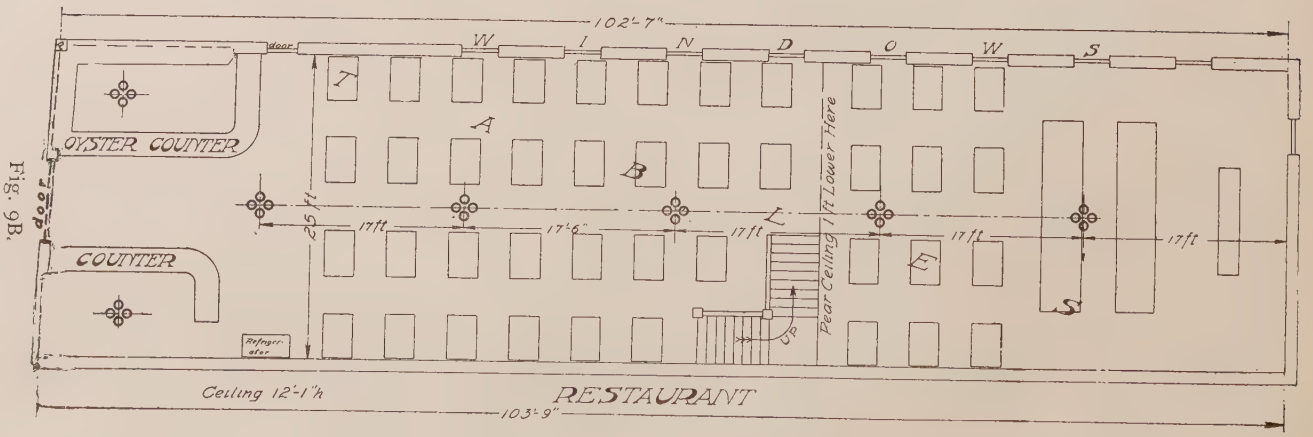
102'-7"
door
W I N D O W S
OYSTER COUNTER
COUNTER
door
17ft
17'-6"
17ft
17ft
17ft
Rear Ceiling 1 ft Lower Here
Refrigerator
UP
Ceiling 12'-1"h
RESTAURANT
103'-9"

Fig. 9B.

Referring to Table No. 2, under the heading of this equipment, with light ceiling and light walls, we have a factor of

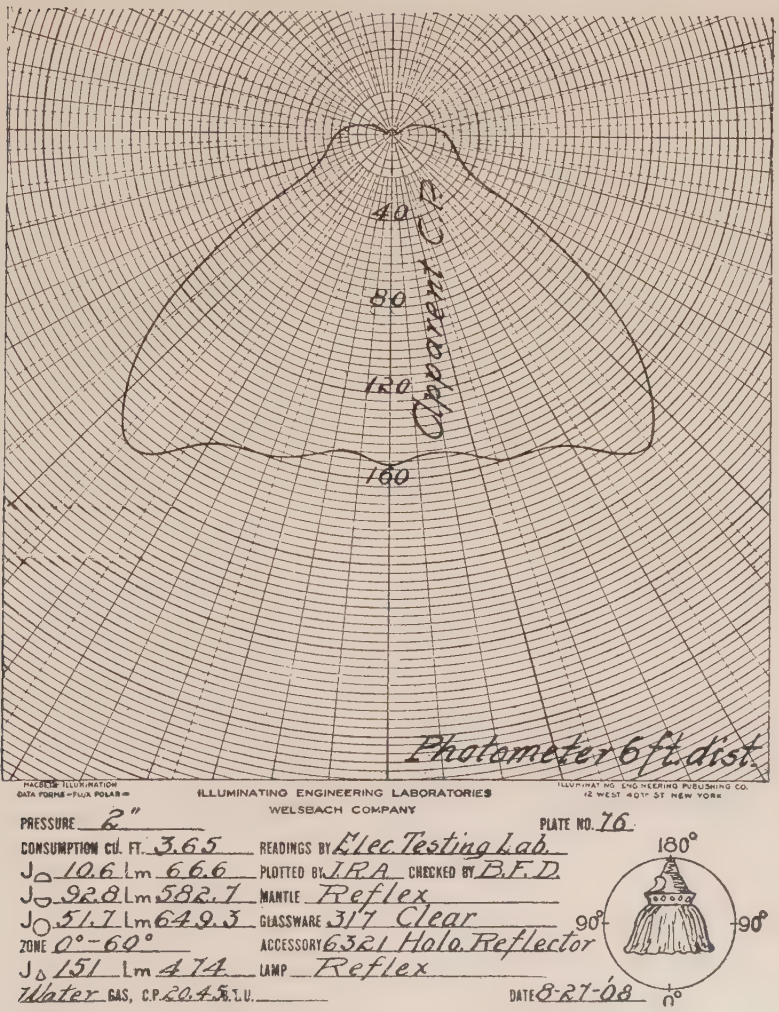

Fig. 10.

110 lumens per cubic foot of gas. The product of the lumens per cubic foot factor and the cubic feet of gas per square foot,

.0597, gives an average intensity in foot-candles of 6.57. This is a brilliant illumination, but not more than is required for the class of goods handled in this kind of store, which in Table No. 1 is given as from 4 to 7 foot-candles.

The first and second outlets from the front should have been moved back 1 foot 6 inches and 2 feet 6 inches, respectively, toward the rear, and all lamps placed 1 foot higher. This would have resulted in a more uniform spacing, and consequently slightly increased uniformity of the illumination.

Fig. 11.

It may be noted that the distance between outlets is about twice the height of the lamps above the plane. With this type of reflector for uniform illumination, the proper ratio has been exceeded.

Fig. 10 shows the light distribution of the single lamp used on these fixtures. In point to point calculations for group or cluster fixtures, it has been found quite satisfactory to multiply the values for a single unit by the number of

units used. This may be done either by increasing the candle-power values, or calculating the illumination from one unit and increasing these intensities in the ratio of the number of units used.

In Fig. 9B and 11 is shown an installation quite different in character to those previously analyzed. The floor has a depth of approximately 103 feet with a width of 25 feet. The ceiling in the front part is 12 feet 1 inch high, with the rear section (approximately 46 feet deep) having a ceiling height 1 foot less, or 11 feet 1 inch. The ceiling is a light "satin-like" finished paper, and the walls are yellow. The height of the fixtures in front is 9 feet 6 inches to center of mantles, and in the rear, 8 feet 6 inches, the fixtures in each case being the same distance from the ceiling. Welsbach-holophane distributing units are employed.

On reference to the plan, it would appear that some arrangement other than that with outlets down the center would have been more desirable. Conclusions based on the general appearance, however, supplemented with illuminometer measurements at the table height in various parts of the dining-room, are to the effect that the present arrangement is quite satisfactory. In fact, the results are much better than if two lines of outlets had been carried down the ceiling, equally spaced 6 feet from the side walls and 13 feet apart. On the side tables the illumination measured 1½ foot-candles, the tables next to the aisle and close to the fixtures ran as high as 4 foot-candles. This variation is not objectionable, nor in fact such as would be noticed by the eye, as the minimum was practically 1½ foot-candles; that is to say, so long as the minimum is not low, the maximum may be five times that amount without criticism; the higher intensity is noted as an addition to the brilliancy of the illumination.

On investigation, we find the area is 2575 square feet, with 7 four-light fixtures installed, taking 93 cubic feet of gas per hour. The total lumens are, therefore, 93 times 110 (see Table No. 2), and the average illumination would be the total

lumens, 10230, divided by 2575, or 3.98 foot-candles. It will be noted that these fixtures were not equally distributed throughout, the front having a greater proportion than the rear. The latter section is used more as a passageway to the kitchen and was not considered as important as the two counters and the entrance.

In the carpet and rug store shown by plan Fig. 12A, we have a length on the main floor of 95 feet 10 inches, with a width of 19 feet 1 inch, a gross area of 1828 square feet. The ceiling height is 12 feet 7 inches, the finish white, with walls practically covered with shelving, showing dark carpets. An effective width between shelving of 15 feet makes the effective area 1437 square feet, with 5 four-light fixtures equipped with inverted mantle lamps with prismatic reflectors, having a total consumption of 52 cubic feet of gas per hour.

Referring to Table No. 2, we find for this equipment a factor of 100 lumens per cubic feet of gas per hour; 52 times 100 gives 5200 total lumens. This divided by the effective area, 1437 square feet, gives 3.62 foot-candles. This is rather low for a store of this character. In Table No. 1, we find it should be 4 to 7, and on again referring to the plan, we find that the distance between outlets (26 feet) is too great (the height to center of mantles being but 9 feet 3 inches) and could be corrected by changing the position of outlets Nos. 2 and 3, moving each to the heavy crosses shown on plan, and installing another four-light fixture at the central heavy cross and shortening all fixtures 1 foot. This would require 5 four-light fixtures, having a consumption of 65 cubic feet per hour, and using the same factor, we have 6500 lumens effective, which divided by the area, 1437 square feet, results in 4.53 foot-candles. In addition to the increased illumination, the uniformity would be much improved, and considering the purposes of display on this floor, the question of uniformity is an important one. The plane of

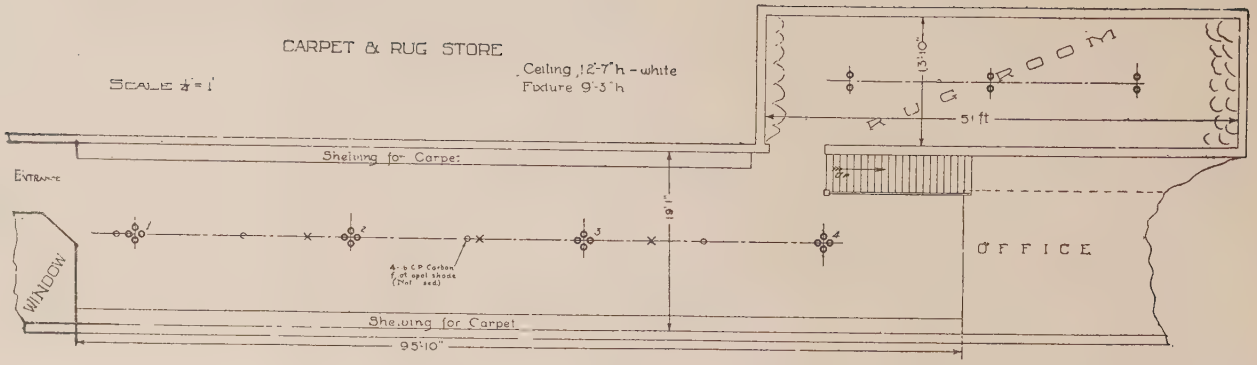

Fig. 12A.

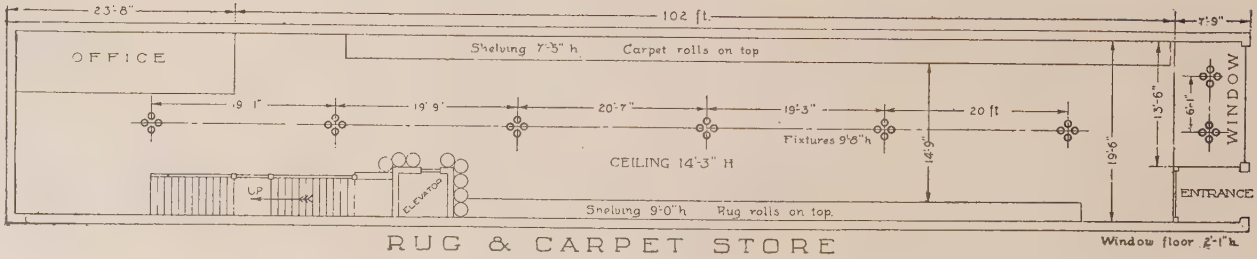

Fig. 12B.

illumination in this distance is on the floor where carpets are displayed.

The rug room in the rear is 51 feet by 13 feet 10 inches, but with an effective length of only 46 feet, due to rolls of oilcloth and matting being stacked up in both ends of the room. The effective area is therefore 636 square feet and 3 two-light fixtures are installed, using the same equipment as that on the main floor, with a consumption of approximately 20 cubic feet of gas per hour. The same factor, 100 lumens per cubic feet of gas, would apply in this section, giving 2000 lumens effective. This divided by the area would give 3.15 foot-candles, and is too low.

Assuming a similar intensity to that desired in the other room, namely, 4½ foot-candles, the calculation would be area, (636 square feet) times intensity (4½) requiring 2862 total lumens. With 100 lumens per cubic foot from this equipment under these conditions, we would require 28.6 cubic feet of gas per hour, and this amount divided by the consumption per lamp, 3⅓ cubic feet, equals 8.6 lamps. The outlet arrangement in this room being otherwise satisfactory, it would merely be necessary to change each of these two-light fixtures to three-light, nine lamps in all, hanging them at a height of 10 feet 6 inches from the floor, (height = ⅗ distance).

It might be added in explanation that this particular store is rarely open after six o'clock in the evening, and as a consequence, the artificial illumination is required merely to help out in the shorter hours in the afternoon, under which conditions the present installation meets the approval of the proprietors.

In Figs. 12B, 13 and 14 is shown another carpet house, in which the treatment from the standpoint of effective illumination is considerably better than the installation just covered. The main floor here shown is 102 feet long by 19 feet 6 inches wide. Making a reduction for elevator, stairway and shelving, the effective area is 1395 square feet. The general

effect in this store appears to be light. However, it will be noted that the heavy rolls of carpet on top of the shelving would give the effect of dark walls; that is to say, the reflection from same would be very low. This interior would, therefore, come into the classification of light ceiling and dark

Fig. 13.

walls. With 5 four-light fixtures installed in the section under consideration, the total consumption of gas would be 65 cubic feet per hour, and with 100 lumens per cubic foot of gas per hour (the factor for this equipment) the result would be 6500 lumens necessary. This divided by the effective area, 1395 square feet, gives an effective illumination of 4.66 foot-candles. This is quite satisfactory; the only criticism which may be made is that on the fixture height, 9 feet 8 inches to center of mantles, with outlets approximately 19½ feet apart. This distance would require the fixtures to be 12 feet high. The general appearance of the room would have been im-

proved had these fixtures been placed at this height, and the effective illumination on the floor plane would not have been reduced, but rather would be improved, judged from the standpoint of uniformity. The latter is a point of importance in a show room where comparatively large areas, carpets, rugs, etc., are to be viewed.

Fig. 14.

For the window, it may be noted from Fig. 12B and Fig. 14 2 four-light fixtures were installed. This method of window lighting is open to criticism. The effect and general results would have been much more satisfactory had the lamps been kept above the plate glass, well toward the front of the window, where the lamps would be out of the direct line of vision, and the light directed downward and back into the window. Reference to Fig. 15 will bring out this point more clearly.

In window illumination problems, the calculation of intensities, either by the point to point method or any other method giving results in foot-candles, is practically impossible, or at

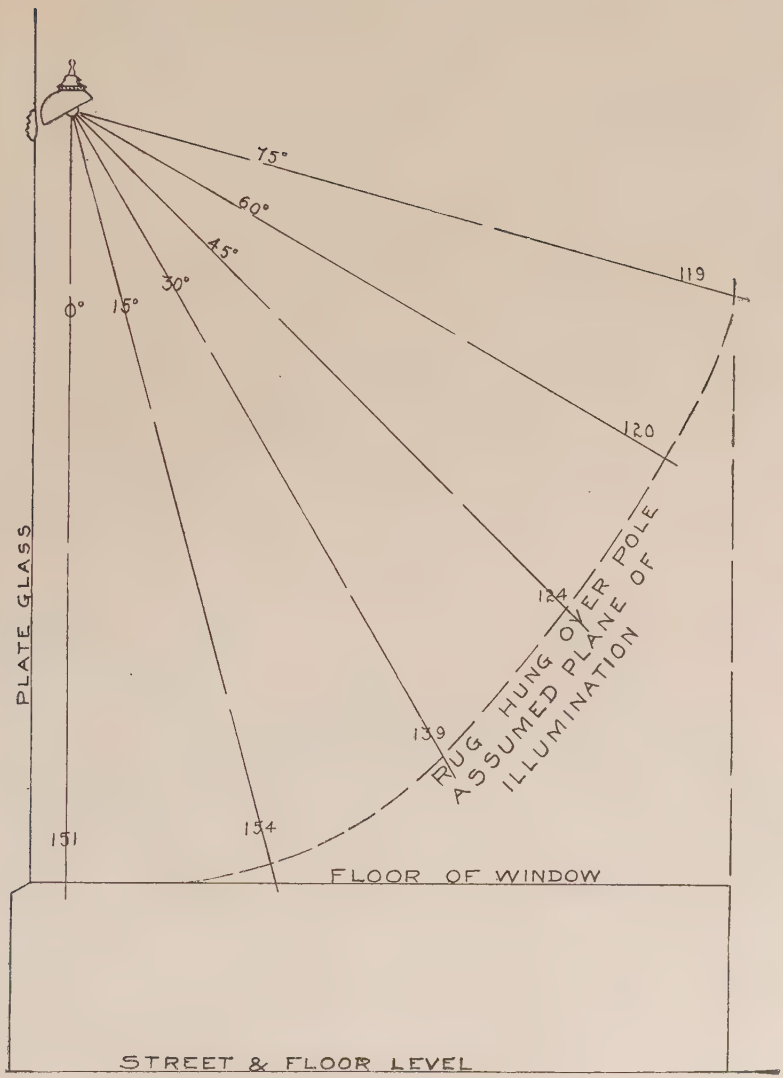

Fig. 15.

least impracticable. The better method is that based on "experience factors," so-called, of cubic feet of gas per square foot of window floor area, assuming in all cases that the

lamps are properly installed and equipped with reflectors of a character to direct the light properly throughout the window, with intensities proportionate to the height and depth of the window and the goods to be shown.

This method is shown in Fig. 15 and consists of laying out a sectional elevation of the window, sketching in the assumed plane of illumination, and measuring the length of the line from lamp center to this plane at the various angles agreeing with those generally used in plotting a polar distribution curve, that is, 0°, 15°, 30°, 45° and 60°. The length of these lines, squared, is then a measure of the intensity required to produce normal uniform illumination. If it is required to increase the intensity at any part of the window, a proportionate increase may be applied to these values at the corresponding angles. These values are then plotted on polar co-ordinate paper and can be very readily compared with distribution curves of known units.

The curve from the calculation shown in Fig. 15 is given on Fig. 16 as the dot and dash line A. The dotted line B is the curve Fig. 17, which is the distribution curve of an inverted mantle lamp and a 30° angle shade. It then remains to place the lamps along the front of the window, the number of these lamps being determined by the calculations before mentioned. These "experience factors" vary throughout a wide range from .12 of a cubic foot of gas per square foot of floor area to about .6 of a cubic foot.

This kind of show window should be very satisfactorily illuminated with approximately .25 of a cubic foot of gas per square foot. The area of the window, 104 cubic feet, times .25 would give 26 cubic feet of gas per hour, which divided by the consumption of the lamp, 3⅓ cubic feet, gives 8 lamps. These can then be spaced either at equal distances or not, as desired. An important point is to provide for ample illumination at the sides or ends; the center will be well taken care of by contributions from practically all of the lamps in the row. In spacing lamps, therefore, it should be borne in mind that if

you make ample provision for the ends, the center will be well taken care of.

Fig. 18 shows a very pleasing example of special lighting. This fruit product display is on the side wall about mid-

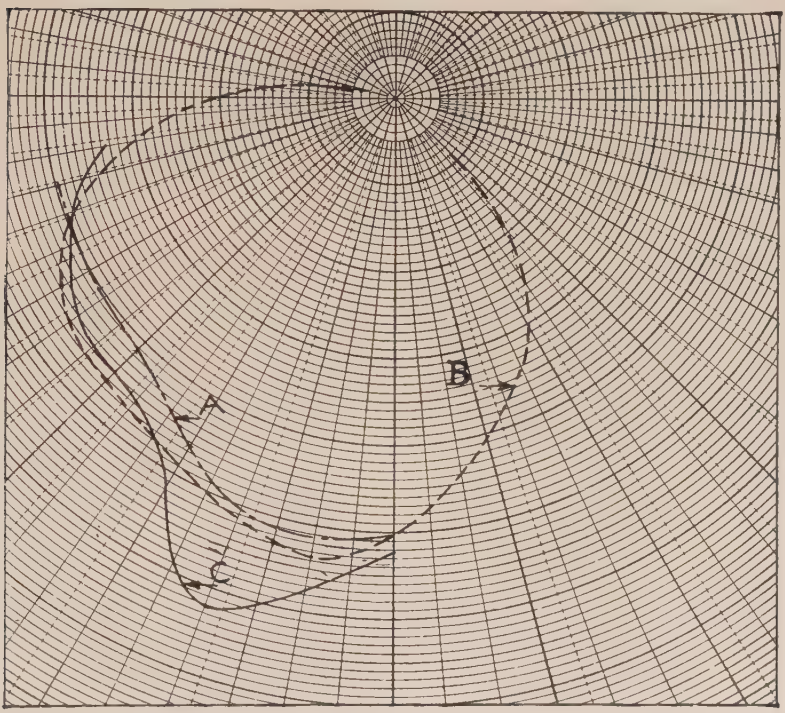

Fig. 16.

way to the rear in a large room, the general illumination of which is derived from very low candle-power miniature electric lamps distributed among the apple blossoms and leaves, with which the entire ceiling and walls are covered. With the high intensity on this display case, approximately 20 foot-candles, and the low intrinsic brilliancy of that side of the source towards the observer, note the total absence of halation about the angle shades, this orchard-like setting with the moon-

light general illumination effect as a background, results in the production of a startlingly novel and beautiful picture.

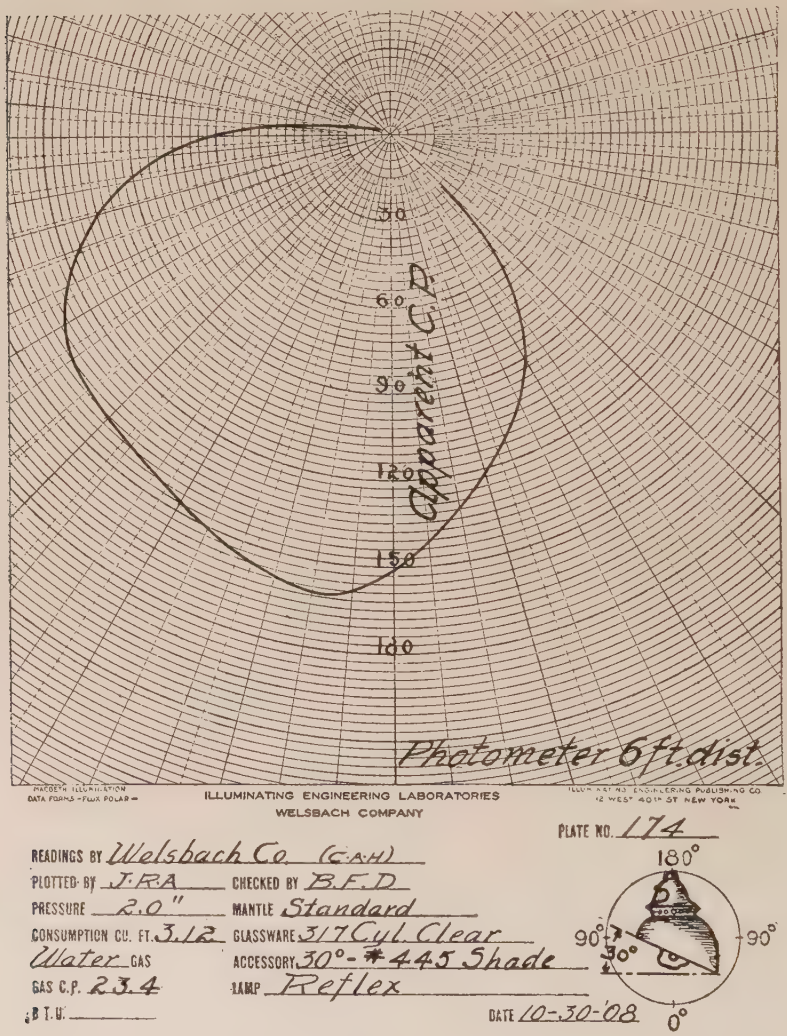

Fig. 17.

Fig. 19 is a sectional elevation of the stand, showing the graphical method of determining the position of the light

source and its required distribution. This stand is approximately 7 feet high and 3 feet 6 inches deep at the base; the

Fig. 18.

width is 5 feet 5 inches, and the inclination of the front is at an angle of 26° from the vertical. Assuming a lamp position of 8 feet from the floor and 6 feet distant from the top of the stand, radial lines are drawn from the center of the light source to the plane of illumination at 5° and 10° angles, as described previously for window illumination problems.

The square of the length of the radial lines measured with any convenient scale, preferably one giving decimal divisions, will supply the values from which the distribution may be

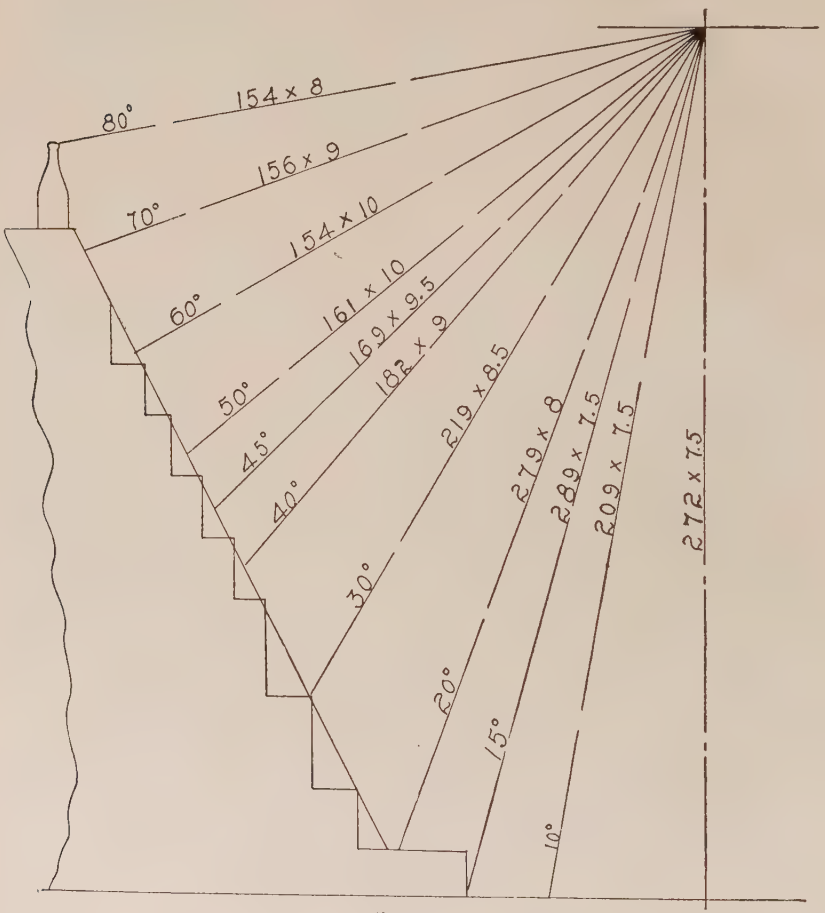

Fig. 19.

determined. In the present instance, the greatest intensity was desired at the height of the observer's eye, 5 feet from the floor, the 50° to 60° angle of the source. Taking this value as unity, the values were reduced by steps to three-quarters on the bottom of the stand.

The specification curve from the values is shown as the solid line curve C Fig. 16, and agrees closely with the distribution curve B, which is that of the unit used. The assumed height and distance of the source proving acceptable, it remains to determine the number of lamps require. The area to be considered (5 feet 5 inches by 8 feet) 44 square feet,

Fig. 20.

assuming .3 cubic foot of gas per square foot, allowing for distribution losses based on a circumscribed circle enclosing the rectangular area to be illuminated, gives 13.2 cubic feet, approximately 4 lamps.

In Fig. 20 is illustrated the type of installation to which the rules and tables given cannot be strictly applied, viz., localized lighting.

Uniformity of illumination is not desired, and the placing

of lamps depends upon the widely varied purposes for which the illumination is required. The size of the source, intensity and direction of light, the placing and screening of same, that the eye may be protected against high intrinsic brilliancy, and other considerations combine in making a field requiring all the experience, judging and ingenuity which the practical illuminating engineer can command.

THE PRESIDENT: The paper of Mr. Macbeth is before you for discussion.

MR. GARTLEY: Mr. President, I want to say just one thing and that is that the result of the scientific study of illumination has unexpectedly brought about some very important things, and has knocked on the head several pet schemes. One of the curious things that has been brought out has been shown by Mr. Marks, an illuminating engineer of New York. He has shown the difference between the necessary amount of foot-candles on a given surface, under daylight illumination and under artificial conditions. It will not do to measure the amount of light that you need in the daytime and say you must have that much at night, because you do not need anything like that amount at night. He has confirmed this point in some instances that he has come in contact with in practical work—he mentions the lighting of a factory where the number of foot-candles that he needed at night was only one-thirtieth of what was attained in the daytime. That, of course, is supposed to be due to the fact that the retina of the eye cannot utilize an excess of light, and depends upon the action of the iris to shut out such excess.

MR. CLABAUGH: I wish to move that we offer a standing vote of thanks to Dr. Hyde for his most excellent lecture.

The motion was seconded and carried by a rising vote.

THE PRESIDENT: I will announce as the

COMMITTEE ON NEXT PLACE OF MEETING,

Capt. Wm. E. Mackay, Mr. J. D. Shattuck, and Mr. F. W. Frueauff.

We will take up the program again in the morning, and we

will make a trial of sectional meetings. There will be a technical meeting in this hall with the first Vice President of the Institute, Mr. Gartley, in the chair. There will be a commercial meeting in the hall, three floors below this, with the second Vice President, Mr. Donald McDonald in the chair. I hope that each section will get out its crowd and have an extremely successful meeting. The meeting now stands adjourned, unless there is more business.

The meeting adjourned at 5 P. M.

SECOND DAY—MORNING SESSION, OCTOBER 21, 1909.

Technical Section.

The meeting of the Technical Section was called to order by Vice President Wm. H. Gartley, at 9.45 A. M.

THE CHAIRMAN: The first paper is a contribution from the laboratory of Arthur D. Little, by Hervey J. Skinner.

MR. SKINNER: This paper which I am about to present is the result of an investigation on the application of tar to roads, which was carried on in the Little Laboratory of Engineering Chemistry at Boston. (Reads paper).

TAR AS APPLIED TO THE SURFACE TREATMENT OF ROADS.

CONTRIBUTION FROM THE LABORATORY OF ARTHUR D. LITTLE, BY HERVEY J. SKINNER.

The problem of preserving the surface of roads and highways and the prevention of dust has been given attention by highway engineers for many years, but not until the year 1905 was the question seriously considered in the United States. The increasing use of automobiles and motor vehicles about this time introduced a new condition to be considered in the building and preservation of roads. Reports from various parts of the United States, England, France and wherever the use of motor vehicles had become common, showed that the automobile was exerting an extremely destructive effect upon road surfaces.

The macadam road has especially been subjected to this destructive action since it is the form of construction most commonly adopted for modern thoroughfares. The binder or fine material upon the surface of the road is removed by the constant passage of automobiles, thus exposing the larger stones, which become loose and which are either left on the surface or in windrows along the sides of the road. The roughened surface presents greater resistance to traction and allows water to percolate to the foundation of the road, thereby seriously injuring the whole structure.

Up to this time the macadam form of construction had been very satisfactory for the character of traffic for which it was designed, namely, that of iron-tired horse vehicles. In a perfectly constructed macadam road, the rock used is so adapted to the kind and amount of traffic that the fine material worn off from the rock replaces that which is removed by atmospheric agencies. Under ordinary conditions, it has been possible to maintain a hard and smooth surface at a moderate expense.

The advent of the automobile has changed very materially the character of the traffic. The action of the rubber tires is very different from that of iron tires and practically no dust is worn off to replace that removed by ordinary wear. The great tractive force or shear exerted by the driving wheels of motor vehicles is the main cause of this injurious effect. It has been demonstrated by a series of experiments in which separate speedometers were connected to the front and rear wheels of automobiles, that there is a very appreciable amount of slipping of the driving wheels on the surface of the road. This slipping effect throws into the air large quantities of the fine surface material, which is caught by the air currents generated by the car body and subsequently removed from the road by the wind.

Aside from the disintegrating action on the road, the dust raised by automobiles is a menace to health and a source of great discomfort to those living near much-traveled highways,

especially in residential sections. Another consideration of importance is the damage to property, and instances are recorded where country estates have been disposed of far below their value, and farms and orchards abandoned owing to the dust nuisance.

The increasing number of automobiles each year emphasizes their importance as a factor to be taken into consideration, and consequently highway engineers have given careful study to the necessity of making a change in the present practice of road construction, as well as evolving some method of preserving the surface of the enormous mileage of roads already built.

The increased cost of maintenance resulting from these changed conditions has resulted in a search for some method of surfacing other than that commonly used on macadam roads. Various materials have been proposed and used, some of which are temporary in their nature and are simply intended as dust preventives. Others are more permanent in character and are advantageous in actually binding the surface of the road together, thus becoming an integral part of the structure. Of this latter class, crude oil and tar are the most important and numerous preparations of these materials have been used with varying degrees of success.

Coal tar has been employed in road building for many years. Tar macadam roadways were constructed in Nottingham, England, as early as the year 1840, although under rather crude conditions. Coal tar pavements have been tried in various parts of the United States, but as a rule the results have not been satisfactory, asphalt being found superior as a paving material. In more recent years, tar macadam roads have been quite successful, and this form of construction is now used to a considerable extent.

The application of tar to the surface of a completed macadam road, while comparatively new in this country, was tried in France about forty years ago. The results were rather unsatisfactory, but the practice has been carried on to some

extent at intervals since that time, especially in Italy and France.

In the United States, the first experiment which attracted the attention of road engineers was in the summer of 1905, when a series of careful experiments were made at Jackson, Tennessee, by the United States Office of Public Roads, in co-operation with the city engineer of Jackson, to determine the value of coal tar in the treatment of broken stone roads. The widespread interest created by these experiments led to similar ones in various parts of the country, particularly in Massachusetts, Rhode Island, New York, New Jersey and Pennsylvania.

The variation in the methods of application and the lack of attention to the quality of the tar and the condition of the road, have led to a difference of opinion as to the real value of coal tar in surface treatment.

The methods of applying the tar have varied considerably, but perhaps the one more generally used, especially in the earlier experiments, is to remove the dust and all loose particles by thoroughly sweeping the surface of the road and then applying the tar from an open kettle mounted on wheels and fitted with a portable fire-box. The tar is brushed over and into the surface with stiff brooms, such as are ordinarily used for street work. The kettle is kept in advance of the workmen, and by using two kettles and heating one while the other is in use, the process is made continuous. After allowing the tar to soak into the surface, it is covered with a layer of sand or fine stone screenings. When several hours have elapsed, the road is completed by rolling with an ordinary steam road-roller.

In some places, and particularly in Europe, mechanical means have been employed for applying tar. Some years ago, the Road Improvement Association held in England a competitive trial, in which many of the machines were fitted with ingenious devices. Nearly all of them provided for heating the tar and applying it under pressure by means of compressed air. Some

of them were designed for carrying on the whole operation with one passage of the vehicle. The dust and loose particles were first removed by suction and drawn up into a receiver. The tar was then applied by compressed air and spread over the surface of the road by means of automatic brushes. The fine material previously removed was again distributed over the surface and rolled by the steam-heated wheels of the machine. Some of these machines were drawn by horses, and others, the larger ones especially, were self-propelled.

The method most commonly used at the present time is a compromise between strictly surface application and tar macadam construction, and is known as the penetration method. In this method the surface of the road is broken up by means of a scarifier, new material added to fill ruts or other depressions, and the road reshaped. After a slight rolling without the addition of water, the tar is applied and allowed to stand as in the previous method. A dressing of fine material is then spread over the surface and the road well rolled, with the result that a surface is formed in which all of the spaces between the hard stone are filled with a minimum amount of tar. A road treated in this manner is similar to one built by the tar macadam process, in which the stone and tar are mixed before being laid.

Many of the trials which have been made with tar as a surfacing material have failed because of a lack of appreciation of a number of important details. The structure of the road, its condition at the time of treatment, the traffic to which it is subjected, the character and amount of tar used, are all important factors which are necessary for successful results.

The structure of macadam roads varies according as each engineer has deviated from the original method of macadam construction to meet his own ideas. As a rule, however, the formation of the road is much the same and is of minor importance in comparison with the actual condition of the

surface at the time the tar is applied. The road should be dry and as free from moisture as possible, since water and tar are not miscible in any sense, and if the tar is applied to a wet road, the latter is, so to speak, tar-proof, and proper penetration is impossible. In such a case, peeling of the surface is very liable to result, owing to the tendency of the tar to remain on the surface as a crust. It is equally important that the road surface should contain as little dust or loose material as possible, as the latter will absorb the tar instead of allowing the tar to be absorbed by the road. This again results in the formation of a crust, which under certain conditions will peel off, leaving the exposed surface of the road comparatively free from tar.

The kind and amount of traffic to which different roads are subjected is very variable and in cases where the traffic is particularly heavy or excessive, ruts and hollows are sure to exist. These irregularities in the surface make even rolling impossible, and unless repaired previous to tarring, water will collect in them and soon exert a detrimental effect upon the tarred surface. In many instances traffic has been allowed on the road too soon after treatment, and this alone has been the cause of a number of failures.

The character of the tar is of almost equal importance as the condition of the road. Tars vary widely in composition even when produced by the same process. The character of the coal used, the method of carbonization, and the temperature of distillation, all have a decided influence on the composition of the tar. The value of coal tar in the surface treatment of roads depends almost entirely upon the binding power of its heavy bitumens. Besides these bitumens, there are present other substances, such as water, ammoniacal liquor, oily constituents, including the light oils and the creosote or "dead" oil, naphthalene, anthracene and similar compounds, and free carbon, the proportion of which varies according to the manner in which the distillation process has been carried out.

The presence of water in coal tar has a similar effect as

moisture in the road. If a tar containing water is applied to a dry road, the latter absorbs the water more readily than the tar, producing the tar-proof effect to which reference has already been made. Difficulty is also experienced in handling tar containing an appreciable amount of water, since the water causes foaming, and if the vessel is heated by direct fire the danger of the tar going over the side of the vessel and taking fire is great.

Ammonia is another undesirable constituent, it being alkaline in nature and having a tendency to form with the oily constituents soluble compounds which are easily washed out by the action of the rain.

Naphthalene and anthracene, while they exert no particularly harmful effect as in the cases of water and ammonia, have no binding power and their presence simply reduces the amount of valuable bitumens which may be present.

Free carbon, like naphthalene, has no detrimental effect, but, on the other hand, it is a useless constituent so far as road treatment is concerned, and its presence reduces the binding power and water-proofing effect, since it possesses none of these qualities itself.

The oily constituents of coal tar are valuable to some extent, since they act as diluents. The light oils are more or less volatile and are probably evaporated soon after the tar is applied to the road, but their presence makes the tar thinner and consequently renders their application easier. The creosote oils are also of some advantage, as it is claimed they add life to the tar and prevent its becoming too brittle.

The amount of tar is another important detail, and if more is applied than the road can properly absorb, it will remain on the surface and be taken up by the top dressing with the resulting formation of a crust. Another objection to an excessive amount of tar is that it has a tendency to become sticky in warm weather and slimy in wet weather.

Sand or fine stone screenings have been used as a top dressing in the majority of the trials with coal tar, although

occasionally the fine material removed from the road previous to tarring has been used. Stone screenings are probably the best material to use on a macadam road, since they furnish a dressing of the same material as the road itself.

A comparison of coal tar with other road binders and dust-preventives is somewhat difficult in the absence of really comparative experiments. Some few trials have been made in which different materials were used on the same stretch of road, but in most cases those experiments using such materials have been on different sections of roadways, and consequently the results were not truly comparable.

Another cause for lack of comparative data lies in the great diversity of materials which have been used. As we have seen, the efficiency of a dust-preventive is in proportion to its binding power and, therefore, a comparison of only those materials of approximately the same binding power is justifiable. The various dust-preventives really form a series from water, which has no binding power, up to coal tar and the heavy asphaltic oils, which have the maximum binding power of any of the materials yet proposed.

Water, salt solutions and light oil emulsions are of the nature of temporary binders, and are not to be compared with the more permanent ones, such as coal tar and oils having an asphalt base.

The use of oil has been confined largely to the United States, and by far the greater portion of the work has been done in the West, owing to the proximity of the oil fields which supply oils with an asphalt base. In the eastern portion of the United States the cost of transportation has been so great that comparatively little experimenting has been done with oil. Tar has been used quite extensively abroad, especially in England and France. In the United States, its use has been confined very largely to the eastern and northern states, although the park authorities of the larger cities have used tar to quite an extent.

Experiments have pretty clearly demonstrated that coal tar is

not adapted for the treatment of gravel or soft earth roads, owing to the fact that it does not amalgamate sufficiently well with these materials to bind them together. For roads of this class, therefore, oil has been more successful than coal tar. The use of coal tar has been and must be confined almost entirely to macadam or broken stone roads, and for roads of this nature it is probably more suitable than oil.

Oil, as a rule, has greater power of penetration than coal tar, but its value is dependent in a large measure on its asphalt base, and before its maximum binding power is reached the more volatile constituents of the oil must be allowed to evaporate. This evaporation is a slow process and until it is complete the disagreeable odor of the crude oil will be apparent and more or less objectionable. The use of oil has also received considerable criticism owing to the damaging effect which it has upon clothes and the paint and varnish of vehicles, especially in damp weather, when a greasy, disagreeable mud is formed.

Coal tar, on the other hand, solidifies quite completely as soon as it is cold, and does not depend, except to a small degree, on the gradual evaporation of its volatile constituents for its hardening. It is comparatively free from the objection of being picked up and thrown by the wheels of vehicles, and although it has a decided odor which lasts for a short time after application, this is not particularly objectionable and to most people is much less offensive than that of crude oil. An objection is sometimes raised to the use of tar on account of a fine black dust which wears off of the tarred surface. It is true that such a dust is formed, but the amount is insignificant in comparison with the dust which would have formed if the road had been untreated.

It is claimed that coal tar has a decided antiseptic value, but how much importance can be attached to this feature is questionable. It is reported that an investigation was carried on in France to determine the number of germs present in the atmosphere over a tarred and an untarred road in the same

neighborhood, and the number over the latter was found to be considerably in excess of those over the tar treated section. Crude oil also possesses a similar antiseptic property, but to a very much less degree.

A properly tarred road is similar to an asphalt pavement, although of a more resilient character. The stone is all bonded together by the tar into a smooth, firm surface which can be swept and washed in much the same manner as an asphalt pavement.

The principal agencies which cause deterioration of tarred or oiled surfaces are heavy rain, frost and the decaying organic matter which accumulates on the surface of the road. So far as can be determined, one kind of road withstands the action of these agencies as well as the other.

Water gas tar is used in connection with coal tar, but not to any great extent by itself. It has a greater power of penetration and less of it is required, but it is not so lasting in character. It is really in a class by itself and occupies an intermediate position between the temporary and the permanent binders. In some cases where a limited amount of money is available, or where for climatic reasons it is advisable to treat the road with the idea of its lasting only through one season, water gas tar should prove a valuable dust layer and any extension of its use will undoubtedly be in this direction.

The value of coal tar in the preservation of macadam roads and as a dust preventive, is still unsettled. It is certain, however, that in the majority of cases the life of a treated road has been materially lengthened, and by applying tar the complete rebuilding of many roads at an enormous expense has been avoided.

One great drawback in the standardization of tar treatment is the impossibility of securing a uniform supply of coal tar. Coal tar is purely a by-product and the processes by which it is derived are never run with reference to the quality of

tar produced, but solely to obtain maximum yields of gas or coke, as the case may be.

The impossibility, therefore, of manufacturing tar to meet definite requirements, makes it necessary to utilize the supply available, but in so doing a certain amount of selection can be exercised and changes made whereby some degree of uniformity is obtained. Some attempts have been made to control the quality of the tar, but with rather unsatisfactory results. The manufacture of special coal tar preparations was intended to provide a greater uniformity, but many of these are, in the opinion of those who have used them, very variable, and the success attending their use is not in proportion to the extra price paid for them.

Strictly surface treatment of an already existing road, even under the best conditions, can only be regarded as a temporary expedient, and its use will probably extend only in cases where for financial or other reasons the rebuilding of the road is not justified.

Partial reconstruction of the road whereby the surface is loosened, reshaped and the coal tar applied before the rolling is done, is undoubtedly a method of considerable value and one which will find more general application in the future. Many highway engineers have predicted an entire change in the methods of road construction, but it is difficult to believe that the macadam method, which has been so universally and so successfully used for a long time, can be eliminated. It is more probable that some modification of the macadam form of construction will be adopted, in which event the tar macadam method is sure to be one of the first to receive serious consideration.

THE CHAIRMAN: Mr. Price has some lantern slides which he will exhibit.

(Mr. Price then exhibited a number of stereopticon views).

THE CHAIRMAN: This is a most interesting subject. There are some gentlemen here I know who have their own ideas on tarring roads, and a good many of them have had experience

in that work. In order to start the discussion, I will ask Mr. Fulweiler if he has anything to say.

Mr. Fulweiler: There are some one or two questions I should like to ask Mr. Skinner in regard to his paper. I should like to ask him whether he does not think the black dust that has often been urged against the use of coal tar as a road surface treatment is not due to the excessive amount of free carbon with which the mixture is charged, and which is carried away by the traffic. There is another point, and that is the advantage of a machine to mix the materials. I might say that I saw the Government using a concrete mixer in New York last summer with very good results is another mixer that I believe will give even better results, and that is the Fulton mixer, which has double paddles and seems to give a good turning motion.

Mr. Skinner: I never had any experience with dust to determine whether there was free carbon in it, but I should doubt very much if there was. I should think it was probably the fine surface material that wears off, and I should doubt very much whether it had any relation to the amount of free carbon in the tar.

The Chairman: Mr. Waring; will you tell us some of your experiences?

Mr. Waring: We have had a very successful experience in Omaha. I will not take up your time to describe our methods in detail, but I do not believe that there is any tar produced in any gas works that will not be beneficial to a roadway. Of course, the better the tar the better the results. We started in Omaha as an educational method four years ago to paint roadways, and now we have educated the people to wanting a permanent paving. A large amount of this is being done, and I have been personally very much interested in this disposition of tar, and think this is the greatest opportunity to find an outlet for all of our product. I think every gas man can do this work himself, it is missionary work which will help us all. As to the different qualities of tars, I think

that we are not yet in a position to state just what these tars should contain; and, as tar is a by-product, I doubt very much whether we can get exactly the best without further expense in the operation of our plant. I do not agree, however, with Mr. Skinner when he speaks about water gas tar not being as good as coal tar, because I think water gas tar is better. I would like to know in what way it differs if brought to the same point of distillation. If it is not as good, he must have some data on that subject. We have been using water gas tar successfully in Omaha for 4 or 5 years, and we find it very satisfactory.

Mr. Skinner: On what kind of roads?

Mr. Waring: All kinds of roads; we use it on dirt roads very successfully. We have a great many miles of dirt roads. They are rounded up, and the tar is put on by a painting process. On cinder roads the tar is put on both by the painting and the penetration process. On macadam roads it is put on as described in the paper.

Mr. Skinner: I think most of the work in Massachusetts has been done on macadam roads, and in this case I think the coal tar is much more satisfactory than the water gas tar. On gravel or soft earth roads, water gas tar I believe has been used very successfully.

Mr. Price: I should like to ask the previous speaker whether he takes any measures to get the odor from the water gas tar, whether he uses it crude or partially distilled? If so, how far he carries the distillation?

Mr. Waring: I think you will find that the odor in water gas tar will largely disappear when the light oil is distilled off. In the penetration system we bring the water gas tar down to the point where it has the same consistency as heavy coal tar.

The Chairman: Mr. Waring, you refer to the water gas tar, not as a tar as it comes from the separators or the tar well, but to a prepared water gas tar in which the water and some of the lighter oils have been distilled off. Is that correct?

MR. WARING: We take the tar as it comes from the separators and we remove all of the water and the light oils that contain this offensive odor, and after this is done it is ready for the painting process, put on by a sprinkling wagon. If we want to use it for the penetration system, we carry the distillation still farther until it has the consistency of the coal tar that is used in the penetration system.

MR. BLAUVELT: I should like to ask the last gentleman the method for binding this water gas tar to the dirt road. He paints them, he says, is that to keep the frost out of the road, and does it prevent injury by traffic during the winter time? In other words, does it do anything more than make the road dustless in the summer?

MR. WARING: We paint the dust roads. They are rolled up, and we paint them with a sprinkling wagon, one gallon for every 3 sq. yds. This is done in hot, dry weather, and it makes them not only dustless, but weedless and also it prevents mud. It puts a water-proof coating on, so that the water, instead of penetrating, runs off to either side of the road. As to the frost, the roads are in good condition in our climate all winter; we practically have no rain in Omaha from about the 1st of November until about the 1st of March, and very little snow; so that, while this practice may be beneficial in our climate, it may not be in other climates where they have thawing and freezing as they do south of the Ohio river.

MR. PRICE: I should like to ask Mr. Waring if he thinks the character of the oil used in making water gas tar has anything to do with the quality of the water gas tar; whether he thinks an asphalt base is any improvement over a paraffin base.

MR. EGNER: I want to say something about this tarring of roads. I am not now connected with the Norfolk Gas Co., but I live in that city, and I notice that we have particularly good roads. The road bed is treated with water gas tar,

and it makes those roads, many miles of them, dustless and very comfortable to ride on.

Mr. W. A. Aldrich: With reference to this water gas tar, there seems to be some little misapprehension as to what it consists of. As to the mixture of water gas tar and coal gas tar, there is no difference, so far as application to macadamizing roads is concerned. The gentleman who replied to so many questions seemed to be misinformed as to what water gas tar really is. After you distill your water gas tar, as far as the odor is concerned, you can tell water gas tar from coal gas tar. Water gas tar is as useful and practical as coal gas tar. The mixture of water gas tar and coal gas tar makes the finest combination for a road that it is possible to make, if the proper care is exercised in the mixing. Some of our finest roads can be seen in Canada, and it is time that we gas men did something else than talk about tar for roads. I think we ought to go home and get into the tar business. I heard of a gas tank out in Washington with about 200,000 gallons of tar in it. They had nowhere else to put it. I think there is no doubt about it, gentlemen, that a tar macadam road, made with a tar well distilled, well mixed with the macadam, and rolled properly, will make a better roadbed than any asphalt that was ever laid upon the street.

Mr. E. C. Jones: I was not going to speak on this subject, because California is so far removed from the East, and its interests are so different, but out in California we are automobile mad. We have in that state, with a small population, over 27,000 automobiles, and we have, extending from the north to the south of California what has always been known as the King's Highway. We are endeavoring to improve our roads to keep up with the growth of the automobile business.

In coal gas tar we have phenol; there is none in water gas tar. I believe no man in an automobile going at the usual rate of speed can tell whether it is coal gas tar or oil gas tar used in making the road. In California we have a natural

product known as bituminous rock, it consists of 80 per cent. of sand and 20 per cent. of infiltrated oil. We used that many years on our sand foundation for road making, and it proved very unsatisfactory. The natural mixture of oil and sand is not nearly so satisfactory as the artificial mixture. We are now using asphaltum on the city streets, but our California petroleum, with an asphalt base, for country road making. We found that we have to plow our roads. We plow them to a depth of a foot and we sprinkle with oil in large quantities. The oil is kneaded into the road by large rollers covered by teeth, so that we have the original macadam surface thoroughly mixed with asphaltum. The sun evaporates the volatile parts of this oil to a certain depth, leaving the asphaltum base firmly mixed with this original roadbed, giving us a road which will stand up for a long time under the terrific wear of automobiles. In answer to the question about fixed carbon on roads, I do not believe any analytical action takes place on a road surface.

THE CHAIRMAN: Mr. Jones, what quantity of oil do you use per square yard?

MR. JONES: It varies considerably, depending upon the original construction of the road; it runs as high, I should say, as a gallon and a half to the sq. yd., for merely surfacing, up to, I should say 4 or 5 gallons where the road is plowed down. We are making roads last a long time in California.

MR. RICE: There has been quite a little said about education, but I haven't heard anybody tell us how we are going to educate. It seems to me that the only way is to educate the people that are running the towns, townships and counties, by going out and building a little stretch of road for them, and showing them. That is what we are doing. We have just finished a couple of blocks in Joliet of tar macadam, and donated to the city the tar, the engineering, and the labor of putting on the tar, to show them that tar macadam is the thing. In the west they don't know what it is, and, on account of the proximity of the oil fields, they are mostly

putting on oil, which is very unsatisfactory to everybody but the people who have the contract for putting it on. I noticed in a Chicago paper the day before I came away that out in Oak Park a lady made a complaint to the town authorities that her carpets had been ruined by the oil. It seems that an automobile had blown up a tire in front of her house and the man came into her house to use the telephone. He dragged the oil all over the lady's carpets, said, "thank you," and departed. That is what oil does. We must go to work and persuade the people out there to stop using oil, and use tar instead, and the only way to do this is to use the same commercial methods in this tar macadam business that we use in the matter of our appliances, etc.

The Chairman: This subject of tarred roads is one of many in connection with roads that are occupying the attention of the people. We must have better roads, because we require higher speed. There is no doubt that a great many roads are very badly tarred at the present time. I recall a case in which it appears that a man, who was a hotel proprietor, had evidently read somewhere that tar was good for roads, bought some tar and put it over a road that had dust on it about 2″ deep. The wagon of this man, and probably of a good many others, acted on the road with a spinning wheel effect, and the tar was thrown all over the wagon, horse and the harness. We must come to a better understanding of what we need. If it is a bitumen that we need, if the binding quality is found in the bitumens, we must use those oils or tars probably that have the most bitumen in them. How to test the tar for use on roads is a question, but the Office of Public Roads in Washington have written a good deal on the subject, and are very much interested. The Government and the States also have discovered that the value of farms and property generally along good roads is enormously increased, so that it pays very well to do it. I think, Mr. Jones, that the state of California has found that money spent on roads is a most excellent investment.

MR. JONES: The state of California this year has appropriated eighteen million dollars for road improvements.

THE CHAIRMAN: Is there anything further that anyone wishes to say on the subject?

DR. ELLIOTT: Mr. President, I have listened with a great deal of satisfaction to this discussion. I had the good fortune this summer to be in the south of England where they have a number of these roads. I have had nothing to do with road making, I do not know any thing about it, but I noticed one or two things that I think extremely interesting. I had the good fortune to meet Mr. Maybury, the county surveyor of Kent, and I traveled over about 120 miles of roads that he had fixed. The way he fixes the roads is extremely simple. First of all, he takes a macadamized road and repairs it, rolling it well. Then he takes a large kettle of tar, and it is immaterial to him, apparently, whether it is water gas tar or coal gas tar, for he uses both indiscriminately. But I think he said he preferred water gas tar, provided that the volatile matter and water were properly taken out of it. The machine that I saw him using, and that made a splendid road, was one that I suppose would hold about a hundred gallons of tar, kept hot by a coke fire and put upon the roads at a temperature of about 185 degrees Fahrenheit by the thermometer. The tar was put on the road with a pump at probably 20 to 30 lbs. pressure. The tar was spread upon the road approximately a quarter of an inch thick, and then a cart followed immediately after with sand and spread the sand evenly all over the road. He told me that that road was good for 2 years. I think this is a very simple method. They certainly make good roads in this way in the south of England. You must remember, however, that the south of England is a chalk country; their roads are chalk roads and they are pretty good roads to start with, but they get into ruts from the automobile traffic. I expect to learn more about it, because I am promised some of his reports. I want to testify to the simplicity of the opera-

tion as he does it and the good results that follow. They are beyond question.

Mr. Price: I should like to say in connection with the English treatment of roads that two members of the Massachusetts Highway Commission went abroad to the Paris Good Roads Convention. They also went all through England on a road hunt, and they saw the machines, the method of application, and everything that could be seen in connection with the methods now in use in England. They purchased 2 machines similar to those used in England at a cost of $4,500. They brought them back to this country, but they have had them all this season and have not yet tried the British methods, for what reasons I have never asked, but I doubt very much whether the English method of making these roads would survive a season in this country. They put on one-eighth of a gallon per sq. yd., and with the roads in this country it is hard work to make them stand up a season with less than half a gallon.

In connection with this tar question it would perhaps interest the gentlemen here to know the extent to which it is being used in New England. They are building tar macadam roads now in 6 or 7 cities in Maine; Lewiston, Westbrook, Hallowell, and a number of other cities and towns under the direction of the state highway commissioners. In Massachusetts they are letting several contracts, amounting to 60,000 gallons on one road. At Providence, R. I., the contractor gets his tar from the gas works in barrels; he finds it more economical to own his own barrels, having over a thousand. The state of Maryland is about to let one contract for 180,000 gallons of tar for one single stretch of road 8 miles in length. This shows how much tar they will use if they once get started.

Mr. Andrews: In regard to tar macadam pavements, we put down a great many miles of such pavements. We have found from long experience that one feature is absolutely necessary in all roads of that character, namely, a good

foundation. Too much stress cannot be laid on this point, and, under the latest specifications, we are now putting in rock concrete foundation; as we would for asphalt pavements. We found in that way that the cost is increased less than 50 cents a yard, and we get a foundation that will last indefinitely. If the tar macadam wears out it is simply a matter of replacing two or three inches instead of digging down to get a good foundation again. We had one case where for the foundation, the ground under the street having a very poor bottom, the contractor rolled in rock until he had 8 or 9 inches. Before he got through with the job it began to show signs of rolling, and in 2 years the street was practically a wreck. Such work gives the whole tar macadam proposition a black eye, and it could have been saved by the expenditure of very little additional care and money. I cannot urge too strongly on all going into this treatment of roads, to insist on a good foundation first. Mr. Jones, I think, has found the same thing in California, that it is absolutely necessary to get a foundation or you will find the road will very soon break up.

THE CHAIRMAN: Gentlemen, we shall have to close this discussion of a very interesting subject. The next paper is by Mr. Chas. D. Lamson.

MR. LAMSON: Mr. President and Gentlemen,—The paper which I propose to read you was the result of a series of experiments which have been tried at Worcester during the last year. It was read before the Society of Gas Lighting, and the Technical Committee of this Association asked me to read the paper here.

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A POUND OF COAL.

Read before the New York Society of Gas Lighting, September 9, 1909.

I have decided to give this paper the title of *"A Pound of Coal"* rather than "A Description of A Retort House."

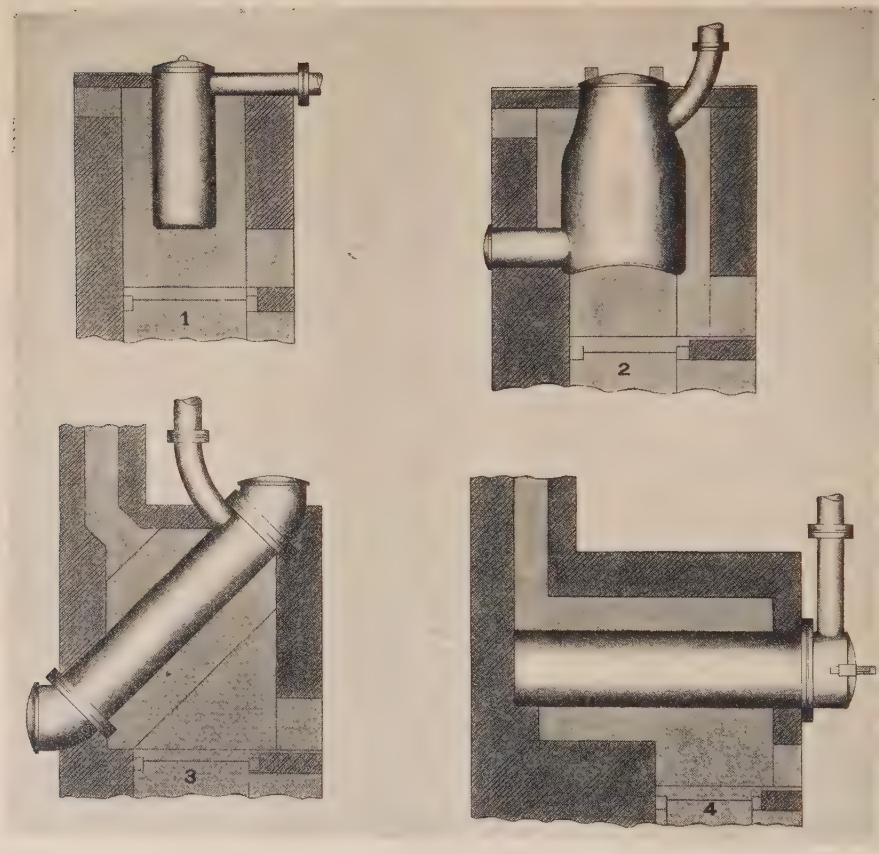
While our new retort house has enabled us to obtain the

remarkable results here recorded, other engineers in different parts of this country and in Europe are developing many new ideas in the way of retort houses, retort stacks and machinery for the production of coal gas, obtaining many most excellent results. I do not wish to criticise them or make any claim for our retort house as compared with them. I wish to make a simple statement of the house and apparatus, and give some of the results we have obtained in practical working,—results, which almost from the start have increased my respect for the pound of coal, and have led me to wonder and regret that we gas engineers have so long been contented even in these later days, when the study of economies is so much in vogue on every hand, with 4¾ to 5 feet per pound of 14 to 14½ candle gas, when 5.90 to 6 feet of 16 to 17 candle gas can be obtained from the same pound of coal. In other words, contented with 75 to 80 candle feet when 95 to 100 candle feet, possibly even more, not only may be, but *is daily* obtained in the new retort house in Worcester.

Let us use the title "A Pound of Coal" and see what we can obtain from it in horizontal retorts. Although I noticed in a recent number of a prominent Gas Journal the following statement: "A prominent gas engineer stated that, in view of the recent results obtained in vertical retorts, he thought it a waste of time to discuss horizontal retorts in any shape, with or without machinery, for large, medium or small works, and the sooner all concerned wake up to these facts, the better for these companies and their stockholders."

Clegg, in his treatise on the manufacture of coal gas, writes as follows: "The birthplace of Gas-lighting was Redruth in Cornwall, and the sole merit of its invention—the practical application of coal-gas to the purpose of artificial illumination —is due to Mr. William Murdoch. The exact period at which that gentleman began his experiments on the distillation of peat, wood, coal, and other inflammable substances, is not known. In 1792 we find him manufacturing gas with an ap-

paratus of his own construction, and lighting his house and offices."



In 1798 gas light might be said to have been first used as a commercial and economical substitute for lamps and candles. Mr. Murdoch was at work on various simple forms of retorts for the generation of gas from coal. The following sketches are some of the first retorts used by Murdoch.

The first and second are vertical, the third "inclined" and the fourth horizontal. The last, horizontal position of the re-

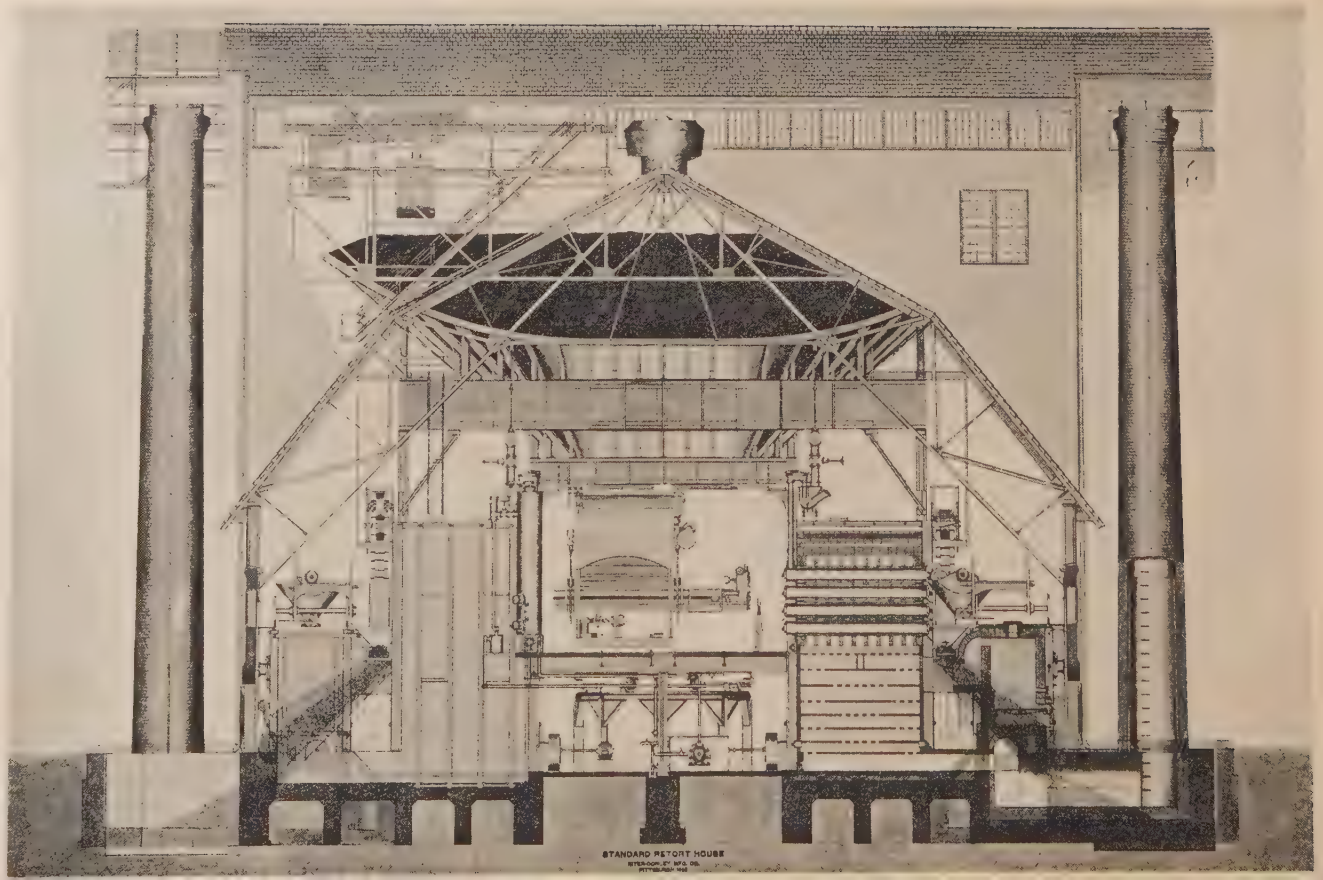
tort for use in the distillation of coal was to continue in favor for many years. Built of many kinds of material, of many shapes and sizes, the horizontal retorts have been in general use the world over. In these later days, various forms and shapes of retorts, set in different positions have come into favor with some engineers. But the horizontal retort still has its very strong advocates, and in this paper (A Pound of Coal) I shall tell of it as carbonized in a stack of horizontal retorts unique in shape, construction and manipulation, but still *horizontal.*

Ever since the early history of gas making, coal has played a most important part in the manufacture and distribution of illuminating gas for cities and towns. In fact, for many years it was the only material from which gas could be obtained in considerable quantities.

With the discovery of petroleum oil, a new and very important factor was introduced. Apparatus for the manufacture of "water gas" became a strong rival in competition with the retort house and coal gas machinery. There was a time, several years ago, when coal was put somewhat in the shade by its later rival. But during recent years, coal gas, because of improved methods of carbonization, has again come into general favor with engineers, and our "Pound of Coal" still holds its high place in producing illuminating gas. Now if we can only get what there is in the coal out of it, and utilize it, it will become again the king among materials for gas manufacture.

It seems strange that in the first fifty years since the practical use of gas in coal by Mr. Murdoch in 1798, so little advance had been made in the art of the manufacture of gas for illuminating purposes.

I think gas was first used in Boston in 1831. I, myself went to the Boston works in 1872. The make of gas could not at that time have reached much more than an average make of four feet per pound of coal. For a long time after that, the yield probably did not reach four and a half feet.


STANDARD RETORT HOUSE

In the early days of my connection with the gas business at the works of the Boston Gas Light Company, the retorts were nearly all made of iron, made with a small flue on each side of the bottom. The flue ran about two-thirds of the way back in the retorts. The settings were three retorts in one arch, and were heated with a small narrow furnace. Very good gas was made. The yield per pound of coal was small. The heat of the retorts "cherry red." For some years before this date, clay retorts of moderate section and lengths were in use in various works and Boston was beginning to experiment with them. With the advent of clay retorts, higher heats were carried, and the number of retorts in an arch was rapidly increased. It was some years, however, before the furnaces were materially increased, and the half depth and full depth furnaces with recuperation became general. There was a steady improvement in the design of retort stacks and, during the last twenty years, the advance has been very great in all apparatus that pertains to a retort house.

The increase in the gas-producing capacity of retort houses has largely come about from the possibility of handling larger amounts of coal to a retort and furnace. In the earlier days of my experience, four and one-half feet of gas per pound of coal was considered very good for a month's working. There was a time, when the New England engineers became stirred up as to the yield from coal, one vieing with another to reach the highest result. Some years ago, at the request of the New England Association of Gas Engineers, I wrote a short paper for the entertainment of the members, entitled "A Cubic Foot of Gas." In starting to write about "A Pound of Coal" I am reminded of the "Cubic Foot of Gas." In referring to it I find on page six the following:

"Well, the race was indeed hot. Neal shook his figures at Slater; Sherman his at Neal. Harbison was not far behind, indeed, I think he claimed to be ahead, 5.10, 5.25, 5.50. Then came the dark horse, Gerould, 5.57, 6.00, 6.10 and—but there —the figures, even now as they come to my mind, cause a

shiver of anxiety as I recollect the stopped stand pipes, the plugged hydraulic mains, underground pipes solid, etc., etc." It is strange, but true, that these men were on the verge of certain facts that might, if proper apparatus had been offered them, have resulted in a very great advance in the industry of gas manufacture. But the resulting troubles from their high heats, pitch, tar, stoppages, choked stand pipes and mains, as well as the rapid destruction of retorts and settings, soon induced more moderate running, and engineers seem very generally to have settled down to a make of 4.85 to 5.00 cubic feet of gas per pound of coal, and a longer duration of retorts.

In the purchase of coal it is generally required that said coal shall yield 4.90 to 5.00 cubic feet of gas to the pound, of at least 15 candle gas, and while plenty of coal men would claim this or even more for their product, we all know that coal which would produce these results or even a candle less in continuous working has been very hard to find. In the Worcester Gas Works, for the past eight or ten years, we have had good retort stacks with half depth furnaces. Clay retorts 16" x 26", 10 feet long. The results from these stacks when in good order, have averaged 4.90 to 5 cubic feet to the pound, of 14 to 14½ candle-power gas. There were times when the results were a little better and times when they were not as good. The coke has been good, and the tar fairly good. I think I am justified in saying that this has been considered generally, a fairly good average result.

It is in consideration of these facts that I am led to write this statement of the results we have obtained in the new retort house that we have built at our works during the past three years.

In our old retort house the "Pound of Coal" gave, say 4.95 feet of 14 c. p., gas, practically 70 candle feet.

In the new retort house the "Pound of Coal" gives 5.95 cu. ft. of 17.0 c. p., practically 101 candle feet.

Coal.

As we have used Westmoreland coal almost exclusively in our Worcester works, I decided to use this coal in all my experiments.

It has seemed to me best to use only one standard coal of well known value, and thus avoid any comparison of coals mined by various companies. During the past few years, I have been able to receive all my coal "all rail." It is never disturbed after it is put into cars at the mines until it is lifted from the cars in our storage house by a large grab bucket. The bucket, in depositing its coal, is lowered to the top of the pile, and the coal is allowed to slip out. It is never dropped, and therefore it is laid down in the coal shed in as nearly as possible the same condition as when put into the cars at the mines. It is not again disturbed until it is put into the crusher on its way to the coal bunker in the retort house. I thoroughly believe in keeping gas coal as dry as possible, and in as large lumps as possible until the time of using.

Over three years ago, I began to consider building a new coal gas plant at the Worcester works. I visited very many of the larger and newer works in this country, and spent some time abroad in looking into the better and more modern forms of retort houses in use there. I made a very careful study of the various forms of horizontal retorts and settings, charged by hand and charged by machinery, also a great variety of inclined retort installations.

I have carefully examined vertical retort plants, both in England and in Germany. I have always been somewhat prejudiced in favor of horizontal retorts, and my investigations have not altered my preference for them. The new retort house at the plant of the Lowell Gas Light Company, in Massachusetts, seemed to me to have some excellent features, and, in fact, I liked this house better in many ways than any other I had seen. The retorts are horizontal. They are of moderate length. They are operated from one end. The machine puts in the coal and pushes out the coke all in one

operation. From the time I first saw the house, I was very much impressed with it, and I decided that the house, with careful working, would produce excellent results. I understand that the results obtained in actual practice have been very satisfactory. One limit, however, to this house, as in many others, has been due to the fire brick material in the retorts and settings. That is,—the limit of heat which may be used with safety to the fire brick material, very materially curtails the capacity of the stack.

I decided early in my own mind, that the general plan of retorts and methods of charging in use in the Lowell house should be adopted in my own retort house when I should build. The Lowell house was built by the Riter-Conley Manufacturing Company of Pittsburg, Pennsylvania. They had done a good deal of work for us and it had all proved satisfactory. I therefore asked them to make me a proposition for a retort house for our works. It was agreed that the general design of the stack used in the Lowell house should be adopted, but it was also agreed that the retorts should be longer, that is fifteen feet in length instead of thirteen, as in the Lowell house. It was proposed to use a new fire material in this stack,—"Ricon"—which will be spoken of later.

The contract for the house was made in October, 1906. It was agreed that the house should be ready to make gas on the first day of October, 1908. The work was carried on quietly and satisfactorily in every way, and it gives me great pleasure to state that the first gas was made, as agreed, on the first day of October, 1908.

The general form of the retort house is entirely the idea of the Riter-Conley Company. It is novel, different from anything we have seen heretofore, and has worked out exceedingly well in practice. The house is designed for two retort stacks of ten benches each, one stack on each side of the house. Only one stack is built at the present time.

The ground on which the house is built being somewhat uncertain, piles were driven for the whole structure. Upon

these piles there is a very heavy concrete foundation. The house is built of structural steel. Along each side of the lower story are placed the large pressed steel doors, two in front of each pair of producers. The main columns of the steel frame are encased in concrete, thus forming pillars between each set of two doors. The second story of the house is of brick, built into the iron work. Above this, the structure is concrete and expanded metal on the iron frame. The roof is covered with tile.

The building is exceedingly well lighted. There are large windows of glass tile in the roof. A line of windows five feet high extends entirely around the house. These windows are easily opened and shut as required. A series of large, low doors on the working floor level, and a set of large ventilators in the roof, all tend to give most excellent ventilation in the house.

There is a large coal bunker in the roof space, capacity 600 tons. This coal bunker is filled from the coal storage house by means of a man trolley and a large grab bucket (Brown Hoist) which passes over a covered bridge from coal storage house. The coal has been carefully broken to small size the largest lumps not larger than 1¼" cube, double tracks for charging machines run through the center of the house. In the middle of these tracks, immediately beneath the coal bunker, is arranged a very efficient turntable, operated by electricity, with a large platform scale built into the same. The working of this combined turntable and scale is exceedingly satisfactory.

The stack of retorts consists of ten benches of eight retorts each. The retorts are fifteen feet long, open at both ends. The retorts are "D" shaped, 16" x 26". They are block, or sectional retorts of "Ricon" material.

There are duplicate charging machines. These machines are fitted with two parallel scoops of peculiar design. The machine has a pocket of 20,000 pounds of coal capacity. Coal is

drawn from the overhead bin by easily handled valves. From this machine pocket the coal is drawn into the scoops for a charge of 900 to 950 pounds, as desired. The machines are worked entirely by electric automatic machinery. As the scoops, loaded with coal, are pushed into the retort, the coke of the former charge is pushed out. The scoops turn over and are withdrawn, leaving the charge very evenly distributed over the floor of the retort, also leaving it quite full. When the coal is heated, the space for the passage of gas above the coal is quite small. (See photograph showing the hot coke in the retort when charge is only half pushed out.) The time taken to charge and discharge a retort is very small.

Coke Conveyor.

When the coke is pushed from the retort, it drops on the conveyor and is carried out of the house. No quenching is done in the house. The conveyor can be easily understood by reference to the various photographs. It is exceedingly simple in form and of very few parts. It practically carries the coke and does not draw or push it. The result is that almost no "breeze" is made. The hot coke is deposited in an iron pocket outside of the house and is then quenched with water from hose. After being thoroughly drained and dried, it is taken out by a large grab bucket arrangement which will be understood by reference to the various plates. The general design of the iron work of the stack can be plainly seen from the photographs.

Since my early connection with the gas business, I have always wanted to try some form of producer operated somewhat after Siemen's plan, that is,—having the producer detached and apart from the retort stack, making gas and sending it forward into the benches to unite with air in combustion under the retort settings. The plans for the retort stacks in this house embodied this principle and I was very glad to adopt it.

There are two producers for each bench. They have large grate area, and a depth of seven feet and three inches of fuel. The producers are at the back of the stack and seven feet away from it. The fuel is coke, but any other form of cheap fuel may be used. The producers are furnished with rocking grates kept in slow motion by an electric motor. A portion of the gases from the main flue of the retort stack are returned underneath the grate bars of producers. *We have been running these benches steadily for a period of eleven months, and so far, the producers have never been opened to clinker them.*

Most of the waste from these fires is in the form of a fine, brownish-yellow dust. A very small amount of partially burned coke drops through the moving grates. This is screened out and returned as fuel. Once in twenty-four hours, the doors underneath the grate bars are opened and the fine dust is removed with a hoe.

The gases from these producers are carried through proper ducts into the retort bench, underneath the retorts, there uniting with the regulated amount of heated secondary air.

In recent years, to obtain large capacity with any one of the new forms of retort stacks, it has been considered necessary to have fairly large retorts, carrying large charges of coal. To work off the gas from these charges, it has been necessary to carry high heats. Some furnaces have been constructed which would produce the necessary heat, but it has been more or less difficult to control the same in such a manner as would ensure an even distribution throughout the whole setting and about the retorts. Further, it has been exceedingly difficult to obtain fire brick material that would stand the extremely high heats for any length of service.

The "Stettin" foreign material is generally thought to withstand more heat than any other, although within a few years there have been several makers in this country who have man-

ufactured material that will stand very nearly, if not quite, the same tests as the "Stettin" stock. I understand that the "Stettin" manufacturers instruct the users of their material that they must not carry a heat of over 2500° Fahrenheit. and at that temperature they must be very careful of retorts and settings.

The contractors, in their plans for our house, proposed to use a new fire material,—"Ricon." They at first proposed that they must not carry a heat of over 2500° Fahrenheit, but later, they notified me that I might, if I cared to do so, carry the heat several hundred degrees higher than this without fear of damaging the settings.

Having arranged for a liberal supply of the best gas coal, delivered into our storage house in best possible condition, and having established a thoroughly equipped retort house with best possible apparatus for working the same, I think we may feel that we are well fitted for the problem we have before us, —that of obtaining the best results from the carbonization of our *Pound of Coal.*

The figures which I shall show you are from a period of eleven months practical working. It has really been a long series of very interesting experiments. It has also been a period of hard work for everybody, and I therefore wish in this paper to give everyone his due mead of praise.

The contractors have from the first made every effort, sparing neither labor nor expense, to make the house a perfect whole. It has not been at any time a question of whether this or that change or improvement was something they could be called upon to do. It has always been, "Will it make the house better or more perfect in its working?" Our own people also deserve our sincere thanks, our Superintendent, Mr. Barnum, who has been untiring in his study and prosecution of the work, and who, with his technical and chemical knowledge, has worked out the heating problem of the stack so carefully.

Our other people, assistants, foremen, chemists,—even the workmen throughout the house it seems to me, have been unusually faithful, and actuated by a desire to do their best to obtain for me the very best possible results from the "Pound of Coal."

Most of the time we have been running seven benches of eights, or fifty-six retorts. The yield is from 5.90 to 6.00 feet of gas per pound, or 17.0 candle-power gas, or over 100 candle feet.

Coke.

The coke from this stack is unusual. It is clean, clear, and hard,—more like "oven coke" than any I have ever seen. We make practically no fine coke for several reasons. First: the coke is very strong, hard, and dense. Then the "coke conveyor" is of such a design that it makes practically no breeze. Our method of quenching and drying also helps to this end.

Proof.

In the working of our former retort houses we made a large amount of breeze. In practice we used this as fuel underneath our steam boilers, and still much was left over, so that when we started our new retort house, we had a very large amount of breeze stacked in our yards. After this new house was started, this pile of breeze soon disappeared, and we were obliged to purchase a regular supply of slack coal for our boilers.

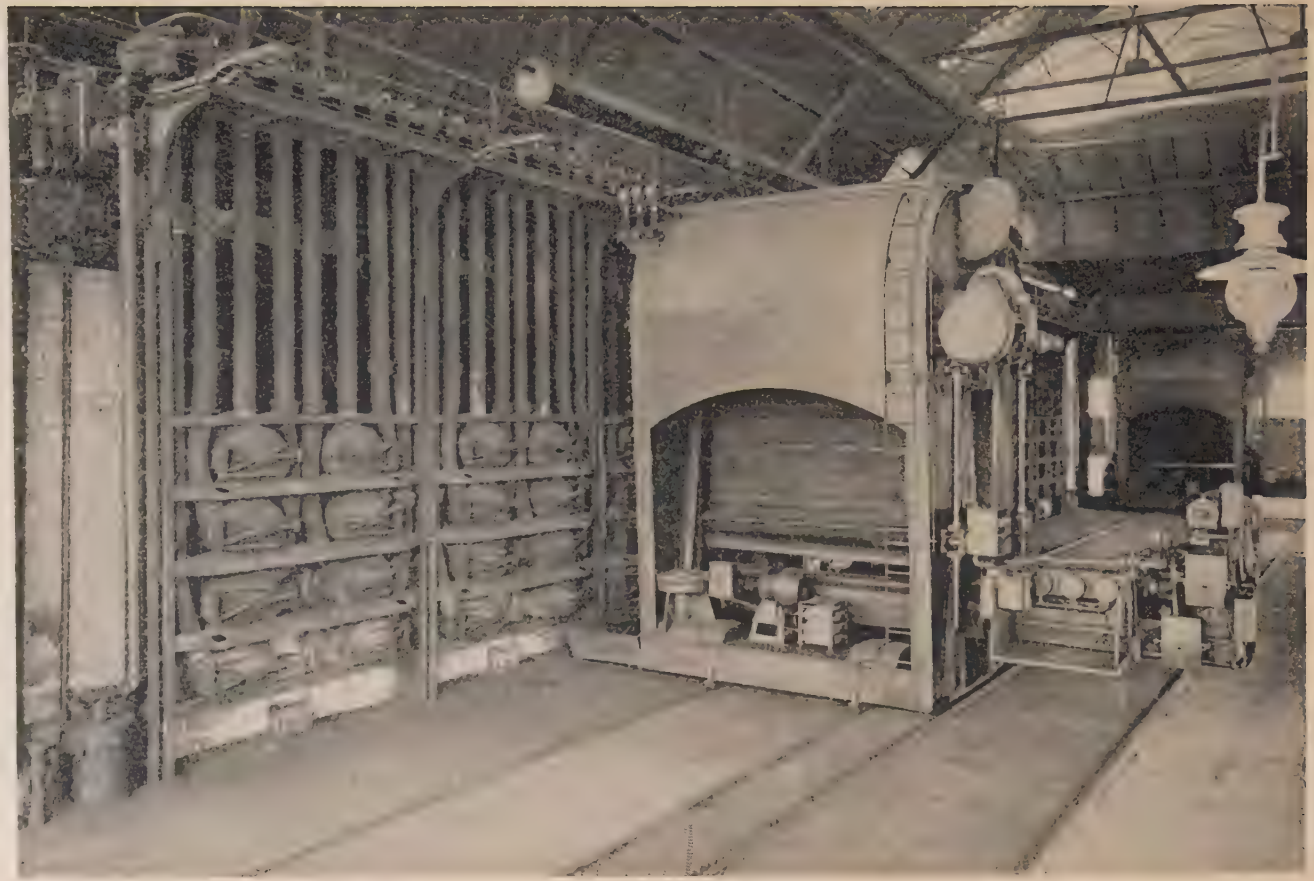
Tar.

The tar from this stack, as it has been running for the past six or eight months, (seven hour charges) has been very satisfactory. This tar is clear and limpid, and easily cared for in all our hydraulic mains, pipes overhead, underground, drips,

etc. The make of tar per ton of coal carbonized is practically between 13 and 14 gallons.

The Riter-Conley Company, in their contract for this retort house, agreed to run the retort stacks in practice during the first two months. They proposed to charge the retorts with 800 pounds of coal every five hours, at a yield of 5 feet of gas per pound of coal, producing 20,000 feet to the retort, or 160,000 feet to the bench in twenty-four hours. They very soon not only reached this capacity, but far exceeded it. The producers seemed capable of generating any amount of heat that was required, with ease, and the recuperation was perfect. Feeling confident in the durability of their Ricon material, they looked forward to reaching very much higher results. They produced at one time as high as 187,000 cubic feet of gas, per bench, and hoped to be able to reach 200,000 cubic feet in twenty-four hours. But there were attendant troubles. Everything in the coal was turned into gas. There were no oils or thin tar in the gas to lubricate it on its way through the works apparatus. The stand pipes, hydraulic mains, gas mains and drips gave much trouble. We were running, I think, with a temperature in the settings of 2850° Fahrenheit. There was no longer any question of the stack as a *gas producer,* but to me, less gas, and a quieter method of running was more agreeable.

When we took possession of the stack, we tried many experiments with different methods of running, and finally settled down to seven hour charges, with from 900 to 950 pounds of coal per retort. This, of course, reduced the yield per bench, but we were compensated for this loss by other advantages. My "Pound of Coal" was induced to give up very nearly the full value of the stock of gas contained in it, and that gas was of very excellent quality. The tar behaves itself in a very satisfactory manner and flows through the pipes and apparatus as it should. The ammonia results are very much improved, and we hope eventually to get a large yield. The average heat in the settings at the present time is 2450°. The



average heat inside the retorts is 2000°—see tables. The evenness of the heat throughout the settings is remarkable. It must be seen to be fully appreciated.

I have thus given a statement of the house, and its practical working for a period of eleven months. During this period, we have tried many tests of every kind. This work has been done by our own chemists and by experts from Boston and also from New York. We have tried to prove our figures before making any statements. I will, at the close of the paper, add some tables which you can consider and work over at your leisure.

The paper is not to be considered as a final statement, as I have said before. We have carried on many experiments and are constantly developing new results. We will, therefore, call the paper a "report of progress." I feel that I have demonstrated what I set out to do—*i. e.,* proved that there is much more value in the *pound of coal* than any of us have given it credit for. I hope others will continue on these same lines of work and add to the results.

Summary.

The stack is capable of producing a very large amount of gas.

In five hour charging we have reached as high as 187,000 cu. ft. per bench in 24 hours.

At our present rate of charging—7 hours—we make 150,000 cu. ft. per bench in 24 hours.

The coke is extremely good.

Practically no "breeze."

Tar is excellent,—clear and limpid.

The yield of gas per pound of coal—5.90 to 6.00 feet. 5.95 cu. ft. x 2240 lbs.—gives 13,328 cu. ft. to ton of coal.

Candle-power, 17.0 This is an average candle-power from

an innumerable number of tests, by different people. The burner used is a Sugg, old D Argand burner, burning 5 cu. ft. of gas per hour. The test of the gas by the English Carpenter burner, called the "Metropolitan Argand, No. 2" gave an average of 18.57 candles. Corrections were made for all the figures in this paper for temperature—60°, barometer—30 in.

Candle feet, 5.95×17.0=101.15 candle feet.

Specific gravity—.440.

B. T. U. 627.

At this year's meeting of the Institution of Gas Engineers held in London June 15th, 1909, I saw it reported that the gas made in the Woodall Duckham plant, also that made in the Young and Glover system is tested with Metropolitan burner No. 2. I think this is as it should be. The gas should properly be tested by the burner best adapted to it, although the Gas Commission seem to think the gas should be tested with a Sugg Argand burner, burning five cubic feet per hour. If we use the Metropolitan burner No. 2 in our experiments, as stated above, expert tests show 18.57 candles. This, with a make of 5.95 cubic feet to the pound of coal, would give 110.49 candle feet.

Coke used in producers, 15 3/10 to 15 4/10 pounds of coke for each 100 pounds of coal carbonized.

Labor. The labor required to operate this house is very small indeed. It would hardly be wise to have a smaller number of men about a house of this size. The ease with which the house is worked in every way is remarkable.

Analysis of Gas.

The following analyses of the gas were made by Mr. C. W. Hinman, former State Inspector of Massachusetts. We have a great many tests made by our own chemists and others, but I thought better to submit these made by an outside expert.

Illuminants	5.59	4.85
Marsh gas	36.12	33.36
Hydrogen	49.23	51.14
Carbonic Oxide	6.31	7.39
Nitrogen	1.52	1.95
Oxygen	0.00	0.00
Carbonic Acid	1.23	1.01

Formula of Hydrocarbon equivalent to illuminants.
C 2.56 H 5.32
C 2.75 H 5.04

Worcester, Mass., Feb'y 16, 1909.

Analyses of Gas Coal and Coke. Laboratory of Worcester Gas Light Company, February 11 to 16.

Coal from Penn. Nos. 2 & 3 Mines.

	Coal No. 1.	Coal No. 2.	Coal No. 3.	Coal No. 4.	Coal No. 5.
Moisture	1.16	1.35	1.38	1.51	1.17
Vol. Matter	34.07	34.30	34.29	34.81	35.12
F. Carbon	58.87	56.09	56.98	56.80	56.76
Ash	5.90	8.26	7.35	6.88	6.95
	100.00	100.00	100.00	100.00	100.00
Sulphur	.78	.76	.78	.84	.96

Sulphur determined by Mr. Keyes.

Coke.

	Coke No. 1	Coke No. 2
Moisture	(Dried)	
Vol. Matter	1.43	2.09
F. Carbon	87.77	87.81
Ash	10.80	10.10
	100.00	100.00

Sulphur .57

Edw. F. Wilson,
Chemist, Westmoreland Coal Company.

Analysis of Tar.

Water	5.25	Specific Gravity	1.24 (28 Be)
Light Oils	1.80	Naphthalene	6.08
Heavy Oils	9.50	Carbon	28.0
Pitch	83.45	Tar taken from a drip 400 feet from the Retort House.	
	100.00		

Temperatures of Combustion Chamber.

Taken by Wanner Pyrometer.

1909 Date Feb.	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
1	2438	2455	2494	2438	2438	2471	2471
2	2422	2422	2455	2438	2422	2494	2455
3	2390	2406	2438	2406	2390	2438	2422
4	2438	2406	2438	2406	2438	2455	2455
5	2422	2390	2422	2406	2390	2422	2422
6	2455	2438	2438	2422	2422	2438	2455
8	2406	2406	2471	2455	2438	2438	2455
9	2406	2406	2438	2455	2438	2422	2422
10	2390	2390	2438	2438	2422	2438	2438
11	2398	2406	2438	2438	2438	2428	2455
12	2438	2438	2438	2455	2438	2438	2455
13	2406	2406	2438	2455	2471	2438	2438
14	2406	2406	2494	2455	2438	2438	2471
15	2422	2422	2438	2422	2455	2438	2422
16	2438	2438	2471	2455	2455	2438	2471
17	2390	2390	2494	2455	2455	2455	2471
18	2471	2471	2494	2455	2438	2438	2438
19	2471	2494	2494	2494	2455	2455	2494
20	2540	2494	2494	2494	2471	2494	2494
21	2455	2471	2471	2438	2438	2438	2455
23	2494	2494	2517	2494	2455	2455	2517
24	2494	2417	2540	2540	2540	2494	2540
25	2438	2438	2494	2471	2471	2471	2471
26	2471	2455	2494	2471	2438	2438	2494
27	2438	2438	2455	2455	2438	2422	2455

Minimum—2390° Maximum—2540° Difference—150°

Temperatures of Combustion Chamber.

Taken by Wanner Pyrometer.

1909 Mar.	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
1	2438	2438	2471	2438	2455	2438	2455
2	2422	2422	2455	2422	2422	2422	2455
3	2438	2422	2438	2422	2406	2422	2438
4	2406	2422	2438	2406	2406	2406	2438
5	2422	2438	2422	2406	2406	2422	2438
6	2422	2438	2438	2406	2406	2406	2455
7	2406	2406	2438	2390	2390	2406	2422
8	2422	2438	2438	2390	2390	2406	2438
9	2422	2422	2438	2422	2406	2422	2438
10	2438	2438	2438	2406	2406	2430	2438
11	2406	2406	2438	2406	2406	2422	2422
12	2422	2422	2438	2438	2422	2422	2438
13	2422	2422	2438	2438	2406	2422	2422
15	2422	2422	2422	2406	2422	2438	2438
16	2406	2406	2422	2438	2422	2438	2438
17	2422	2406	2422	2438	2422	2422	2438
18	2422	2422	2438	2422	2438	2422	2438
19	2406	2422	2438	2438	2422	2406	2455
20	2422	2422	2455	2438	2422	2438	2438
21	2406	2422	2422	2422	2422	2422	2438
22	2406	2422	2455	2422	2422	2455	2438
23	2406	2422	2422	2438	2422	2422	2438
24	2422	2455	2494	2494	2494	2494	2517
25	2422	2422	2455	2455	2406	2422	2434
26	2406	2422	2438	2438	2422	2422	2438
27	2422	2438	2455	2438	2422	2438	2422
29	2406	2471	2471	2455	2422	2455	2455
30	2406	2471	2471	2455	2422	2471	2471
31	2406	2471	2471	2455	2438	2471	2471

Large Yield.

The large yield of gas per pound of coal is due to perfectly

legitimate methods of carbonization; first, the gas is in the coal.

It has been the experience of all gas engineers that if the coal is left in the retort long enough, the yield could be obtained; the charges are left in seven hours, exposed to a heat that will not injure the candle-power. The heats are uniform throughout each square foot of retort floor. The charges of coal are very uniform and evenly laid.

The retort material (Ricon) has over 20% more conductivity than ordinary clay material. We are thus able to get the necessary heat into the retort without having an excessive temperature on the outside, in the setting and in the combustion chamber.

The retorts show a difference in temperature between the inside and outside of same, of 200 to 250 degrees, depending upon the amount of carbon in the retort.

These desirable conditions are obtained and uniformly maintained by having large grate area, large producer capacity and a uniform condition of fuel bed.

High Candle-Power.

This may be explained as follows:

The large charges of coal leave a minimum amount of retort surface to act upon the gas as it is generated, yet enough heat is given to the gas to make the hydrocarbons permanent gases; not only is the relative amount of retort surface decreased by the small space above the coal, but the rate of flow is faster, and consequently the *time* that the gas is exposed to the heated surface of the retort is shorter, all of which tends to decrease the dissociation of the hydrocarbons.

The dissociation is further controlled by the comparatively low heats we are able to maintain, and yet carbonize the coal in seven hours, due to the Ricon fire material.

The above are positive reasons. We see by the analysis that the nitrogen is very low, and that the carbonic acid and oxide

is no more than comes from the distillation. These results are accomplished by keeping as low a pressure in the retort as possible, and yet having the pressure, at all times, slightly more than the pressure in the setting. Four-tenths in the retort and one-tenth in the setting, is what we maintain.

The dissociation of the hydrocarbons is further prevented by the fact that the heats are uniform throughout the entire retort surface; each retort is evenly heated its entire length. There are no points or spots of high intensity.

Balance by Weight.

GAS.

Weight of 1 ft. of air × gravity of gas × feet per pound .0761×.44×5.93=..... .198

COKE.

Coal minus volatile matter in coal plus volatile matter in coke 1.00—.3503+.0176= .667

TAR.

Tar gravity × 8.33 × gals. per ton divided by 2240, 1.1×8.33×13½÷2240..... .055

Hydroscopic Water

Average of analysis of coal ..... .013

AMMONIA.

5.62 lbs. NH÷2240 ..... .0023

SULPHUR.

½ the total sulphur in coal ..... .0065

WATER FORMED.

The ultimate analysis of Westmoreland Coal gives 7.64% oxygen.

The analysis of the gas gives 1.43 carbonic acid, and 6.48 carbonic oxide.

1 pound coal gives 5.95 ft. gas.

1.43 × 5.95 gives .085 ft. carbonic acid.

1 ft. carbonic acid weigh .11637

.085 × .11637 = .0098 lbs.

$CO_2 = 12 + 32$

$O_2 = 32/44 \times .0098 = .0071$ lbs. O_2 for the carbonic acid.

6.43 CO × 5.95 = .382 ft. CO

1 ft. CO weighs .074

.382 × .074 = .0282 lbs.

CO = 12 + 16

$O = 4/7 \times .0282 = .01612$

Total oxygen = .00716 + .01612 = .02328

Oxygen in coal minus oxygen in CO_2 = oxygen in water formed.

.0764 — .0232 = .0532 lbs. oxygen.

This oxygen forms hydroxal HO

The hydrogen would be 1/16 of .0532 or .0033

Total weight HO formed would be .0565

See paper by Porter & Ovitz in Am. G. L. J. Sept. 14, 1908. P. 447.

Balance by Weight.

résumé.

Totals from 1 pound of coal.

Gas	.198
Coke	.667
Tar	.055
Hydroscopic Water	.013
Ammonia	.0025
Sulphur	.0065
Water Formed	.0565
	.9985

BALANCE OF HEAT UNITS.

1 pound of Westmoreland Coal		13500
1 pound of our coke		12779
1 pound of the tar		15943
1 pound of coal		13500
Coke, .667 × 12779	8523	
Tar, .055 × 15943 (14 gals.)....	876	
Gas, 5.95 × 627	3730	
Hydrogen in water formed .0033 × 61523	203	13332
Unaccounted for		168

RETURN FLUE GAS DATA.

Size of producer: 4′ — 1″ × 5′ — 5″ × 7′ — 3″. There are two producers to each bench of eight retorts.

Temperature under grates	500°F
Temperature of Fuel Bed and Outlet Producer	1800°
Temperature of Combustion Chamber...	2431°
Temperature underneath the Top Arch.	2316°
Temperature at top of Recuperation....	2011°
Temperature Main Flue	1058°
Temperature Inlet Blower	950°
Temperature Retorts	2009°
Temperature Secondary Air	1841°

Difference in temperature inside and outside upper retort — 200° — 250°.

ANALYSIS OF GASES.

	Return flue	Oxide flue	Outlet Bench	Main flue
CO_2	9.3	10.0	18.7	15.2
O_2	11.6	0.4	1.1	5.7
CO	0.0	18.7	0.0	0.0
N_2	79.1	70.9	80.2	79.1

The making of producer gas for the heating of the retorts for distilling coal is a very important part of any discussion

of a retort house, and the subject, if considered in its entirety, is not only interesting, but becomes quite complicated and involved if it is followed out to a logical conclusion. The subject may be divided as follows:

The prevention of clinkers.

The generating and transmission of heat.

Economy.

Regulation.

The principal impurities in the fuel that cause the clinkers are silica, calcium, magnesia, and iron. We therefore have the problem of making producer gas and keeping the temperature of the fuel bed below the fusing point of the above.

This may be attempted in three different ways:

First: by mixing waste gases with the non-heated primary air, and regulating the amount of oxygen used per hour per pound of fuel at such a point that while the carbon will unite with the oxygen to form carbonic oxide, the temperature will not be high enough to form clinker or to break up the carbonic acid. We have found that a temperature of 1800° will accomplish this result. This condition can be obtained by regulating the proportions, the amount, the temperature, the pressure and rate of flow of the mixture. This method does away with all clinker whatsoever, and is the method of operating the Worcester retort house.

Second: by using waste gases instead of steam; the heat absorbed by the dissociation of the CO_2 keeps the temperature below a given point.

Third: by introducing steam with the primary air, and the heat absorbed in dissociation of the H_2O keeps the temperature of the fuel bed below the fusing point of the ash.

Producer Gas.

first process.

In discussing the problem of making producer gas, we are, at the outset, confronted with the question of whether the carbon and oxygen unite to form carbonic oxide, and upon further

action to form carbonic acid, or does the carbon and oxygen first form carbonic acid which is reduced upon further reaction to carbonic oxide. From a study of the authorities on this subject, it would seem to be a question that must be decided in each particular case, and the conditions governing are temperature, pressure, rate of flow, and the mixture entering the fuel. Our analyses are made daily with the Orsat apparatus, and care is taken to have the solutions fresh.

The mixture in the return flue and oxide flue show the following:

	Return flue	Oxide flue
CO_2	9.3	10.0
O_2	11.6	0.4
CO	0.0	18.7
N_2	79.1	70.9

The coke gives an analysis as follows:

Dried sample.

Volatile matter	2.08	89.9
Fixed carbon	87.81	
Ash	10.10	

We will first consider the practical case of one of the Worcester producers and will figure the volume of gas passing through per each pound of combustible, the heat that is available from this fuel for heating the retorts, and the total fuel used including that which is necessary for running the blower, and get the net British Thermal Units available per pound of combustible.

We first have the action

$O_2 + 2C = 2CO$

and one volume of O_2 becomes two volumes of CO, omitting the volume C which is negligible. In each pound of fuel, there is .899 pound combustible. One pound combustible requires 1.33 pounds O_2 (Figured on 20.9% O_2 by vol.)

$.899 \times 1.33 = 1.1956$ pounds O_2 required per pound of fuel.

In the mixture there is 11.6% O_2 or .116 foot O_2 per foot of mixture. One foot O_2 weighs .084 pound.

$.116 \times .084 = .00974$

$$\frac{\text{Oxygen required}}{\text{Oxygen per ft. mixture}} = \frac{1.1956}{.00974} = 122.7 \text{ feet of mixture required per pound of fuel.}$$

This 122.7 increases in volume in passing through the producer as one volume O_2 becomes 2 volumes CO and 18.7% CO represents an increase of 12.6 feet, and the 122.7 feet becomes 135 feet.

The secondary air is added to the producer gases and the CO becomes CO_2 thus $2CO + O_2 = 2CO_2$.

2 vol. + 1 vol. = 2 vol. and the 135 feet is increased by the nitrogen of the secondary air.

The analysis shows 18.7% CO

18.7% of 135 ft. = 25.2 CO

$\frac{25.2}{2} \times 4 = 50.4$ N_2 to be added to 135 = 185 ft.

So that we have 135 feet of gas that conveys the heat from the producer to the combustion chamber and 185 feet that conveys it to the retorts.

Producer Gas.

second process.

Assuming that nearly all the carbonic acid is broken up in passing through the fuel.

To break up any CO_2 it is necessary to have a temperature of at least 1877 F. We will assume that all the CO_2 of the waste gas is broken up except 3% and also that we get the same reaction from the oxygen as in the first process.

Return Flue Mixture.

	Per cent.	Feet
CO_2	9.3	11.4
O_2	11.6	14.3
CO	0.0	0.0
N_2	79.1	97.0

The mixture will be increased in volume in passing through the fuel by the oxygen uniting with the carbon and by the carbonic acid breaking up and the producer gas will work out as follows:

ANALYSIS OF PRODUCER GAS.

	Feet	Per cent.
Carbonic acid	5.4	3.7
Oxygen	0.0	0.0
Carbonic Oxide	40.6	28.5
Nitrogen	97.0	67.8
	143.0	

The coke gives .899% combustible and we have seen how there is required 122.7 feet of the mixture for the combustion of one pound of coke.

This mixture of 122.7 feet becomes 143.0 feet.

An additional amount of carbon has been used to break up the carbonic acid thus:

6.3% CO_2 is broken up.

6.3% of 122.7 equals 7.7 feet of CO_2.

CO_2 plus C equals 2 CO.

(12 plus 32) plus 12 equals 2 (12 plus 16).

7.7 feet CO_2 weighs .896 lb.

.896 lb. CO_2 requires .243 lb. C or

27 pound fuel;

therefore for the 143.0 feet producer gas there is 1.27 lbs. fuel or 112.6 feet of gas per one pound of fuel, to carry the heat from the producer to the combustion chamber.

The secondary air is added to the producer gases and the CO becomes CO_2 thus:

2 CO plus O_2 equals 2 CO_2 and the 143.0 feet is increased by the nitrogen of the secondary air thus:

40.6 divided by 2 equals 20.3 or 76.8 N_2 to be added to the 143.0 which gives 219.8 feet per 1.27 lbs. fuel or 173.8 feet per one pound of fuel that carries the heat from the combustion chamber to the retorts.

Producer Gas with Steam.

THIRD PROCESS.

In the case of producer gas where steam is used, we have authentic figures of the amount used per pound of fuel, varying from ⅓ to 1 pound. In the paper by W. A. Baehr, Institute Proceedings of 1907, page 791, there is a table giving 0.42 pound water per one pound fuel, and I take it that this may be considered good practice.

We have seen that the burning of one pound of coke with .899% combustible matter requires 68 cubic feet of air, and that the 68 feet would become 81 feet in passing through the producer. To this volume of gas would be added the gas formed from the .42 pound steam.

Thus:

$H_2O + C = CO + H_2$

$18 + 12 = 12 + 16 + 2$ and the resultant gas would be

$CO = .42 \times \frac{8}{9} \div \frac{4}{7} = .653$ pound
$H_2 = .42 \times \frac{1}{9} = .046$ pound
} equal volumes.

.653 pound CO = 8.8 ft.
.046 pound H = 8.8 ft.
} 17.6 feet.

This will therefore give

$81 + 17.6 = 98.6$ ft.

In breaking up the .42 pound steam we have used additional fuel thus:

$H_2O + C = CO + H_2$

$18 + 12 = 12 + 16 + 2$

$C = \frac{2}{3}\ H_2O = \frac{2}{3} \times .42 = .28$ pound carbon which $= .231$ pound fuel or 1.321 pounds fuel for 98.6 feet of gas which gives 74.6 feet of gas available per pound of fuel for carrying the heat from the producer to the combustion chamber as against 135 in the return flue gas scheme.

In Mr. Baehr's paper on page 796 he quotes from Dr. Fisher the equation

$C + O = CO$

and the composition of the resultant gas would be

$CO = 34.7\%$

$N_2 = 65.3\%$

and we will assume that we will get this proportion. Therefore the composition of our steam producer gas will work out as follows:

	Per cent.		Feet		Feet
CO_2	0.0	×	81	=	0.0
O_2	0.0	×	81	=	0.0
CO	34.7	×	81	=	28.1
N_2	65.3	×	81	=	52.9

From the steam

CO	8.8
H_2	8.8

Which gives

	Feet	Per cent.
CO_2	0.0	0.0
O_2	0.0	0.0
CO	36.9	37.4
H_2	8.8	8.9
N_2	52.9	53.6
	98.6	99.9

The oxygen necessary for the secondary combustion would increase this 98.6 feet as follows:

For the 37.4% or 36.9 ft. CO, $56.9 = 18.4$ ft. O_2 is required and this increases the volume by 69.9 ft. N_2

and $98.6 + 69.6 = 168.2$ ft.

For the 8.8 ft. H_2

$\frac{1}{2} \times 8.8 = 4.4 = 16.4$ N_2

$168.2 + 16.4 = 184.6$ ft. total volume gas per 1.321 pounds fuel or 139.7 feet of gas per pound fuel to convey the heat from the combustion chamber to the retorts as compared with 185 for the return flue gas scheme.

Producer Gas with Steam.

THIRD PROCESS.

If we assume that 1.0 lb. steam per lb. fuel is used, the results would be as follows:

Volume of gas per lb. fuel from producer to combustion chamber would be 70.7. Volume of gas per lb. from combustion chamber to retorts would be 146 cu. ft.

Heating Powers.

FIRST PROCESS.

The heating power of the gas per one pound of fuel for the return flue gas system when the CO_2 is *not* broken up will be:

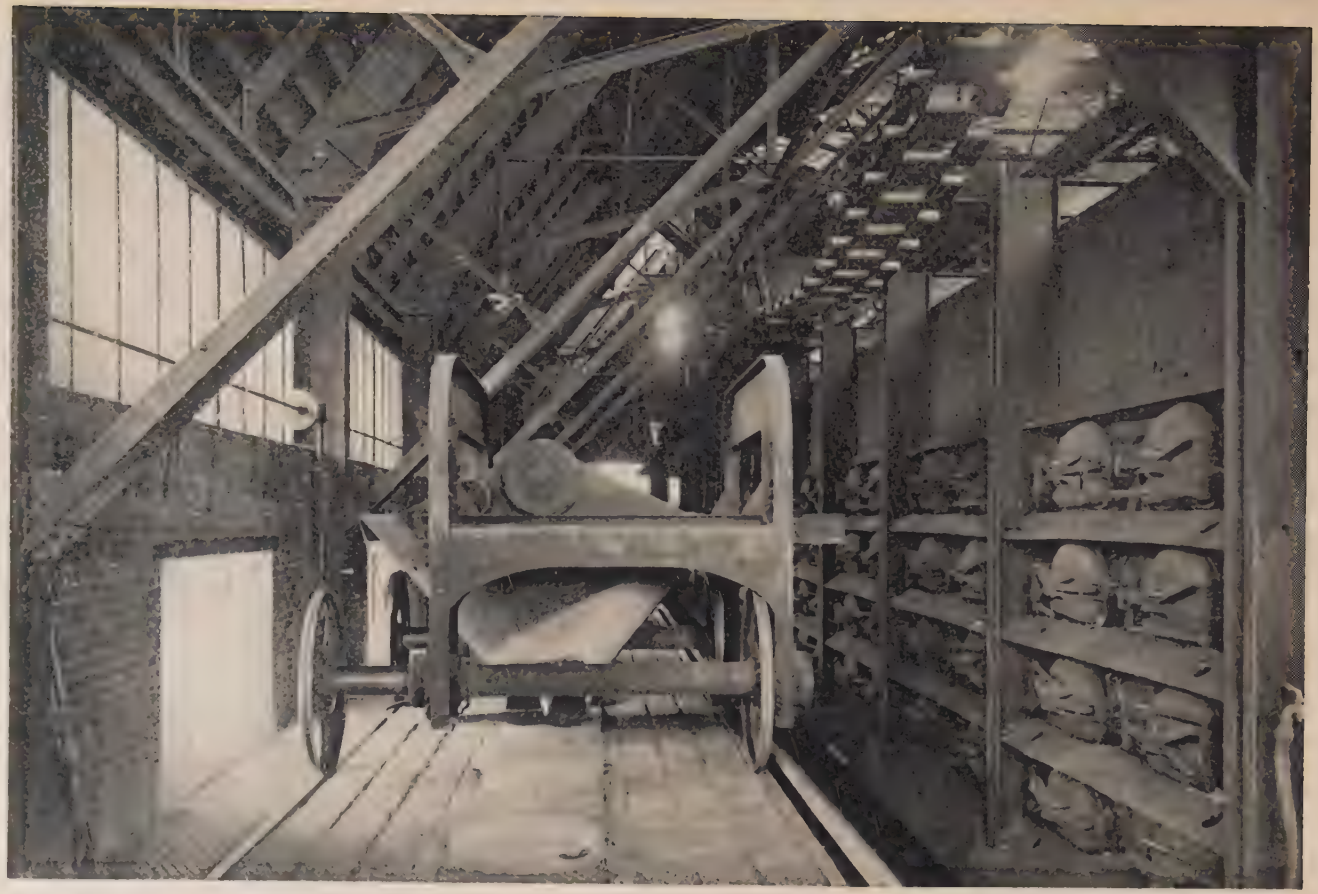
Heat of combustion

$CO = 18.7\% \times 135 = 25.2$ ft.	
25.2 ft. $\times$ 323.5 = ...	8152
Sensible heat	
$CO_2 = 13.2 \times .21 \times 1877 \times .116 =$	613
$O_2 = O$	
$CO = 25.2 \times .24 \times 1877 \times .074 =$	849
$N_2 = 96.2 \times .24 \times 1877 \times .074 =$	3206
Total B. T. U.....	12820

In addition to one pound of fuel above, there is power used to run the blower for returning the flue gases. This was measured and amounted to .96 H. P. per hour per bench, or, at four pounds fuel per H. P. = 92.1 pounds per day per bench, or 92.1 pounds fuel per 24555 pounds coal carbonized = .004 pound per 1.00 pound coal carbonized, or .026 per pound fuel. We therefore have 12820 B. T. U. per 1.026 pounds fuel or 12496 per pound fuel.

SECOND PROCESS.

The heating value of this gas when the CO_2 is broken up will be:



Heat of combustion:

CO equals 40.6 feet	
40.6×323.5	13134 B. T. U.
Sensible heat	
CO_2 equals $5.4 \times 2.1 \times 1877 \times .116$	247
O_2	0
CO equals $40.6 \times .24 \times 1877 \times .074$..	1353
N_2 equals $97.0 \times .24 \times 1877 \times .074$..	3233
	17967

Coke necessary to dissociate the CO_2	
CO equals 15.4×323.5 equals.....	4982
B. T. U. per pound of coke is	12779
4982 divided by 12779 equals	.39 lb. coke.
Therefore we have	
Fuel for combustion	1.00 lb.
Fuel for dissociating CO_2	.39
Fuel for blower	.026
Total fuel	1.416

17967 divided by 1.416 equals 12688 B. T. U. per pound fuel.

THIRD PROCESS.

The heating power of the gas with .42 lb. steam per pound of fuel will be as follows:

Heat of combustion	B. T. U.
$36.9\ CO \times 323.5$	11937
$8.8 H_2 \times 326.2$	2870
As sensible heat	
$CO_2 = O$	
$O_2 = O$	
$CO = 36.9 \times .24 \times 1877 \times .074$	1228
$H_2 = 8.8 \times .409 \times 1877 \times .0053$	358
$N_2 = 52.9 \times .24 \times 1877 \times .074$	1763
Total B. T. U.	18156

We have used 1877° in all three cases as that is the temperature at which the CO_2 and H_2O starts to break up, and it thus serves for comparing the results in all cases under the similar conditions.

We thus have 18156 B. T. U. per pound fuel for the combustion plus what fuel is necessary to make the .42 pound water into steam and dissociate it, thus:

$CO = 8.8 \times 323 = 2842$

$H_2 = 8.8 \times 327 = 2877$

5719

Latent heat 1 pound of water = 966

$.42 \times 966 = 405$

$5719 + 405 = 6124$ B. T. U.

One pound of coke developes 12779 B. T. U.

Therefore 6124 will take .49 pound coke.

Coke for combustion	1.00
Coke for steam	.49
	1.49

$18156 \div 1.49 = 12453$

THIRD PROCESS.

The heating power of the gas per 1 lb. fuel when 1 lb. steam per lb. fuel is used instead of .42 lb. steam, will be 12609 B. T. U. per lb. fuel.

TABULATED RESULTS.

	Feet, gas, from producer to combustion chamber	Feet, gas, from combustion chamber to retorts	B. T. U. per pound fuel
FIRST PROCESS.			
Not Breaking up the Carbonic Acid	135	185	12496
SECOND PROCESS.			
Breaking up the Carbonic Acid	113	174	12688
THIRD PROCESS.			
Producer Gas with .42 lb. water per lb. fuel	75	140	12453
THIRD PROCESS.			
Producer Gas with 1.0 lb. per water lb. fuel	70	146	12609

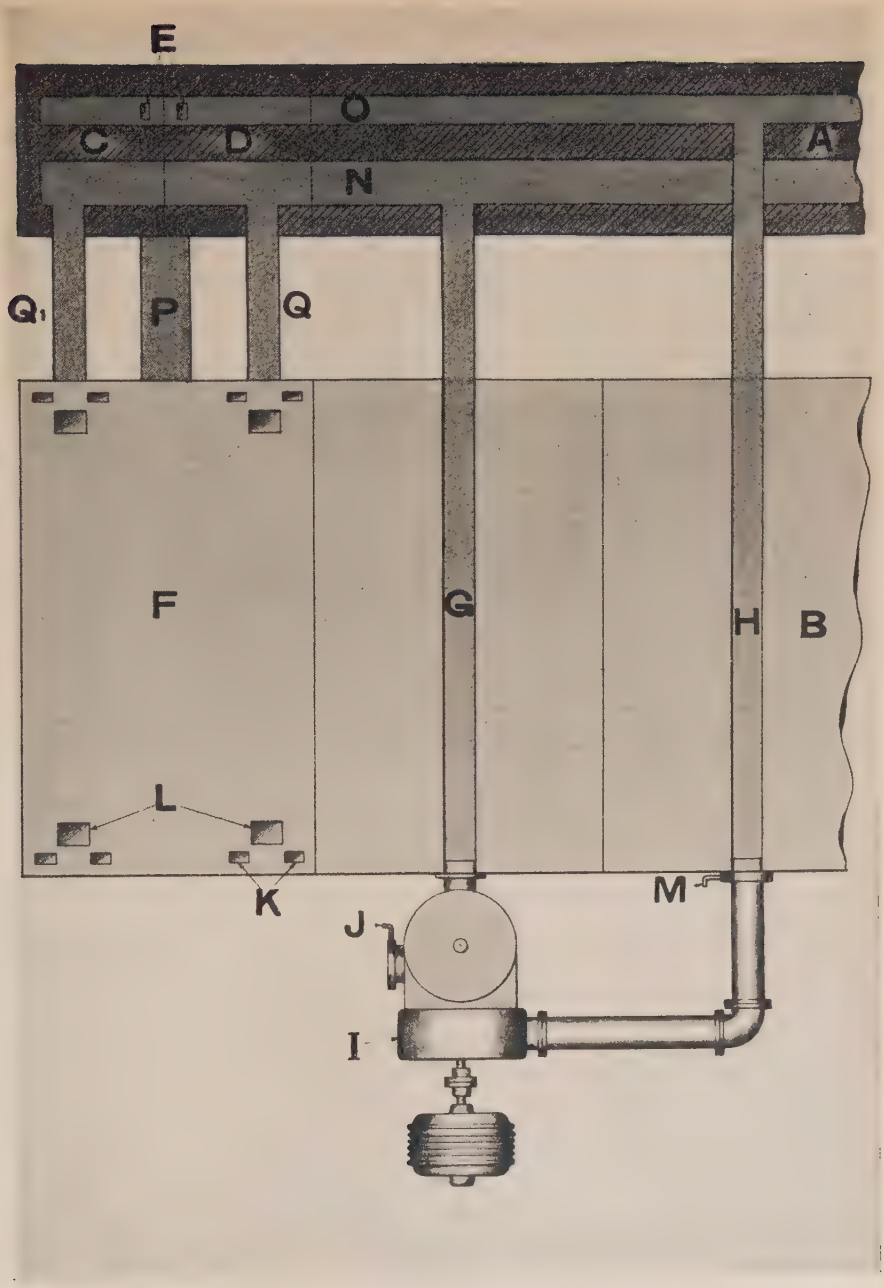
We therefore find that comparing the actual case of return flue gases with the theoretical cases of steam, assuming 100% efficiency for the latter, that the advantage of one over the other is within the errors of sampling, analyzing and calculating.

The fuel results for the month of March were 15.4 pounds per 100 pounds, or 25.8 lbs. per 1000 feet gas, and for April,—15.3 per 100 and 26.3 per 1000 feet. This result is found by measuring the coke in 22 bushel buckets as it comes from the retort house, and using 38 pounds per bushel.

Two men days and two men nights not only take care of the rear end retort lids and the feeding of the producers, but they attend to all the work on the producers of seven benches, and as there is a twin producer for each bench, this means 14 fires, or 3½ fires per man. The total absence of clinker insures a uniform activity of each square foot of fuel on the great area, and of each cubic foot of fuel in the producer. The above, together with positive regulations, fixed openings, and constant speed of blower, make possible a uniform and constant amount of producer gas of a constant heating value, going forward to the combustion chamber at all times. The amount of heat not only remains constant, but the volume of gas also, and this is fully as important as the former.

In starting the benches, the usual precautions are followed: drying thoroughly, getting the nostrils red hot before closing coaling holes and keeping an excess of secondary air in the setting.

The producers are run without any waste gases until a temperature of about 1200° is obtained, care being taken not to raise the temperature over 200° in twenty-four hours. At this stage, the blower is started and run at a constant speed by means of an induction motor, and a pressure of one inch is maintained in the return flue. Under these conditions, the primary air opening will be about one-half what it was before the blower was started. This will give close to 10% CO_2 in



A—Furnace stack. B—Retort stack. C & D—Twin producers. E—Dampers from return flue to producers. F—Bench of 8 retorts. G—Flue from main flue to blower. H—Flue from blower to return flue. I—Blower. J—Primary air inlet. (On the inlet to blower.) K—Secondary air inlets. L—Stack dampers. M—Pressure regulating damper. N—Main flue to chimney. O—Return flue. P—Oxide flue. Q_1 & Q—Flues from bench to main flue.

the mixture entering the producers, which is a convenient point to regulate from.

Having started the flue gases with the primary air, the given mixture of O_2, N_2, and CO_2 provided the producers are kept full, will set up a certain temperature in the producers and will give a fixed amount of gas and heat travelling to the combustion chamber. To increase the temperature in the combustion chamber, the primary air and amount of mixture is increased until the requisite temperature is obtained. After getting the approximate temperature required, the amount of opening of the dampers regulating the mixture under the grate bars and the pressure in the return flue is adjusted to give the requisite volume of producer gases, and the desired per cent. of CO_2. Then the pressure in the settings must be adjusted by the individual stack dampers so as to obtain a slight pressure. We then adjust the secondary air dampers to give a slight excess of oxygen at the outlet of the bench proper. After the above changes are made, the primary air may need some slight re-adjustment. We have found that with seven hour charges of 900 pounds, using hot coke from the gas coal, that the following conditions are the most satisfactory:

CO_2 in R. F. 8—9%

Pressure in R. F. $\frac{7}{10} - \frac{1}{10}$

Excess O_2. 1%

Pressure in settings $\frac{1}{10} - \frac{0}{10} \pm$

Having obtained the proper regulation, and provided the producers are kept full, the temperature in the combustion chamber will not vary 60° F. from the normal.

The reason for this is as follows:

The amount of oxygen entering the system is automatically controlled to within very narrow limits, and it follows that with a given amount of fuel in a uniform condition the amount of heat and volume of gases going to the combustion chamber is constant.

The manner in which the oxygen is controlled is as follows:

The air enters at the inlet of the blower and through the secondary air ports. If the primary air at the blower increases, the amount of producer gas going to the setting increases, and as the stack openings will only take care of a given volume, the amount of secondary air is therefore decreased, and consequently, the surplus secondary air which goes with the waste gases back to the producers is decreased, and offsets the increased amount of primary air. This action is reversible. That is,—if the primary air is decreased, the volume of producer gas decreases and more secondary air is drawn in, and the surplus passes on to the producers with the waste gases.

The temperature in the retorts may vary 75° due to the character of the coal and the size and weight of the charge, but with a constant temperature in the combustion chamber, and a constant volume of producer gases, if the coal and size of charges are maintained within reasonable limits, the temperature in the retorts will be uniform throughout the same retort and the same in all the retorts, and they will not vary from day to day to any appreciable amount.

In closing I must ask that you excuse any deficiencies in this paper. It is made up from a mass of data, all of which is interesting, but only a small portion could be brought before you. I hope the description of this Retort House will induce you to visit it. I also hope the figures given from the experiments will be of interest and that you may strive to get even better results from the *pound of coal.*

The Chairman: I think it would be well if we asked Mr. Africa to read now his paper on

Vertical Retorts,

so these papers can be discussed together.

Mr. Africa then read his paper as follows:

REPORT ON VERTICAL RETORTS.

In 1908, two benches of vertical retorts, of the intermittent charging type, were completed at the Manchester, New Hamp-

shire, Gas Works, each bench consisted of nine retorts, 8″ x 14″ at the top and 12″ x 18″ at the bottom, 18′ 6″ long. An illustration and further description of these benches is given in a paper on Vertical Retorts by J. H. Taussig (American Gas Institute Proceedings, 1908, page 564). One of the benches was operated a number of months during the year and demonstrated that the furnace and recuperators were entirely satisfactory. The size of the retorts was in the nature of an experiment, as no vertical retorts of which we have any record had been tried heretofore with American coal.

The size of the retorts adopted was made small, in order to carbonize the coal in the shortest time possible and obtain through short charges a greater capacity per bench per 24 hours.

The small retorts did not prove to be entirely satisfactory with Run-of-Mine West Virginia coal, which was used during the tests. The charges were burned off in 6 hours but would not discharge without some poking both at the top and bottom of the retorts. Tests were made of screened coal of uniform sized lumps which worked much more satisfactorily.

In order to determine the best size of retort to carbonize American coal, the nine small retorts were removed and replaced by five of different sizes and tapers, having a capacity varying from 1,000 lbs. to 2,200 lbs. of coal per charge. These experimental retorts have been under fire for several months and demonstrated that a retort 10″ x 14″ at the top and 15″ x 21″ at the bottom, 18′ 6″ long gives the best results, discharging entirely satisfactorily in 9 hours and in a large percentage of the trials discharged in 8 hours, indicating that if the benches were fitted with retorts of a uniform size and operated continuously and regularly, it would be conservative to figure on 3-hour charges.

The vertical retorts were under fire at the same time the horizontal benches were in operation and both gases handled by the same exhauster.

In order to determine exactly what results the verticals were giving, a 5′ station meter was connected in such a manner

that the gas from these retorts was pumped by a separate exhauster through this meter. This test was made during the latter part of June, 1909. A connection was made from this meter to the photometer room and a sample of the gas purified by oxide was passed through a 30-gallon mixing tank and from this tank to the bar photometer. A pentane lamp was used as a standard. For several days, hourly readings of the photometer were made.

The analysis of the coal (West Virginia) used at Manchester is as follows:

Moisture	1.25%
Vol. Comb.	39.30
Fixed carbon	53.85
Ash	5.60
	100.
Sulphur	:76
Cal. Value	14,640 B. T. U.

Analysis of coke from 9-hour charge:—

Moisture	.10%
Vol. Comb.	2.40
Fixed carbon	89.20
Ash	8.30
	100.
Sulphur	.85
Cal. Value	14,329 B. T. U.

The continuous hourly test gave the following results:—

Yield per pound of coal	4.82 cu. ft.
Candle-power (measured with a flat flame burner)	16.08
Candle-feet per lb.	77.51
Calorific power, B. T. U.	635

Carbonizing, 45% of capacity of setting.

Yield of coke and fuel used in furnaces was as follows:—

Per cent. of coal carbonized used in furnace	23
Total coke made per cent. of coal carbonized	61

The tar obtained was thin and contained about 7% of free carbon. The coke is of a better quality than obtained from horizontal retorts and produces less breeze.

The cost of labor per thousand cubic feet will compare favorably with that of machine-stoked horizontals.

The plans are completed for refilling the two benches with retorts of the size described above, and when these are in operation a further report of the results will be made.

THE CHAIRMAN: Gentlemen,—These two papers are before you for discussion.

MR. WHEELER: Mr. Chairman, I have had the pleasure of visiting Mr. Lamson's works, and was charmed by the beautiful exposition he has there of scientific gas manufacture. I was struck with the great difference in the B. t. u's., and the volatiles of the coal which Mr. Lamson uses, compared with the coal used by Mr. Africa. There is a difference of 6 per cent. in the volatile matter, and of over a thousand in the heat units, yet Mr. Lamson gets 5.95 to 6.0 feet per pound, corrected, and Mr. Africa only got 4.82. Mr. Lamson speaks of the low pressure that he carries in his retort; that is one of the reasons why he gets his high candle-power, but I should like to ask Mr. Lamson if at any time during the past year he has automatically controlled that pressure at the time that he discharges the retorts by throwing on extra pressure, by means of a valve system and flooding his hydraulic main with liquor, so as to increase, temporarily, the pressure on the retorts while the discharge and recharging of retorts is taking place. That is a very important point, and it seemed to me while I was there that his foreman threw the lever and changed the pressure almost an inch by some method of temporarily flooding his main. It is a very important point because he kept his candle-power and also his B. t. u.'s very even by this method.

He analyzes the three processes of making gas, three systems of handling gas from the producer into the benches, and he is very specific in describing the Worcester method, and then

he speaks of a second method of using waste gases in dissociating the carbonic acid; and later he analyzes the chemical factors and arrives at a table in which he gives the B. t. u's. per pound of fuel consumed. Now, of course, in doing such analytical work there is always an error which is likely to creep in, but it seems to me that in the first process he has figured 12,496 B. t. u's. per pound of fuel, and in the second process 12,688, showing an increase. Taking the physical factors given, and running through the calculations rapidly, the figures that I make are 13,000 in round numbers for the first process, and 13,400 for the second. Of course, that is a proportion well within the limits of errors in calculation, yet it is a very significant thing, because the second process, apparently, produces a great many more B. t. u's. than the first process. The extraordinary evenness of the heat is very remarkable, and the ash produced is fine and clear, while the labor cost is very low. It is a remarkable example of scientific principles carried out in a careful and scientific manner by a highly-trained technician. It is an object lesson, not only in the construction but in the operation, of a superb plant, with a chemical balance and a thermometer in use all the time.

THE CHAIRMAN: Mr. Fowler, have you anything to offer?

MR. FOWLER: We have listened to Mr. Lamson's description of the new retort house at Worcester and his statement concerning the results obtained and the reasons therefor with the greatest interest and pleasure. I, for my part, congratulate him on the possession of the most efficient and best looking horizontal Retort House in the world, and I also wish to express my appreciation of the technical, scientific and inventive ability of the engineers who designed and erected the plant, which marks a new departure in the manufacture of coal gas.

The daring and confidence which guaranteed a production of gas equal to more than 1300 feet per running foot of

horizontal retort excite our heartfelt admiration, and command our highest praise.

The fuel used in the bench measured in relation to the coal carbonized seems rather high, but measured in relation to the candle feet produced from the coal it is very low. In the new bench the fuel record is better than it would have been in the old bench if they had used therein only 11 pounds of fuel per 100 pounds of coal carbonized.

In comparison with the plant at Worcester ours is a very modest one, but a few remarks concerning it may be of interest.

The carbonizing plant of the Charlestown Gas & Electric Co., consists of six half depth benches of eight through retorts, each fired from internal furnaces at each end of the bench. The grates are 5′2″ below the bottom retorts and are 5′ long and 12″ wide. There is a division wall through the middle of each bench which makes the two ends of the bench independent of one another so far as heating is concerned.

The retorts are 15″ x 26″ x 20′ 0″ long and are set in the benches in two vertical rows. Standpipes are provided at one end of the retorts only. Five standpipes serve the eight retorts of each bench; the top retorts each having a standpipe 8″ in diameter, while the other six retorts are connected in pairs to three standpipes 10″ in diameter.

The width of the arches is 7′6″ and the thickness of the partition walls is 18″, making the arches 9′0″ from center to center.

The block, settings and retorts are of fire clay material, furnished by Adam Weber Sons Co. The settings are open. The whole plan is the same as that of the Weber half-depth six retort bench, except that there are more retorts and that the furnace is slightly enlarged. A full description of the plant as it then existed was read at the Meeting of the New England Association of Gas Engineers in February, 1906, and can be found in the technical papers of about that time. It was originally intended to operate the house by hand ex-

clusively, but little by little it has been changed to a machine house.

In the old retort plant, which consisted of 12 benches of 6's 9 ft. long, and which occupied the exact area of the present block, we made a gas which required considerable enrichment to bring it to a safe margin above the 16 candle-power required by the Massachusetts law, and in starting the new plant in December, 1905, we continued to use oil in cartridges. But we soon found that no enricher was necessary. We therefore discontinued its use in February, 1906, and have used none since that time, with the exception of about three weeks and then we couldn't see that it did us any good. It was difficult for us to find out exactly what we were doing during the first year and a half after the benches were started, for we did not make all the gas we sent out. The only Station Meter we had was used to measure the gas we bought from the Boston Consolidated Gas Co. But when that Station Meter was not in use for the Boston Co.'s gas, we made some tests of which the following, by Dr. Wing of the Boston Co., and Mr. Haddock of the Cambridge Co., is an example.

MAY 20, 1906.

Two benches of eight retorts each in operation. Coal carbonized in four hours 11,200 lbs. Gas made per lb. of coal 5.0178. Average candle-power 17.99. Candle-feet per lb. of coal 90.27. Temperature of Gas at Station Meter about 70°.

This was with four hour changes of 700 lbs. each per retort. The burner used for testing was a Sugg D. with low ring.

At this same time, as you will have noticed by Mr. Lamson's paper, he was getting in Worcester about 70 candle-feet per pound of coal. We both buy the same kind of coal, except that he gets his all rail and from some particular mine openings which he has reason to believe produce an especially good coal. My coal is a mixture.

So far as I am able to judge, a yield of approximately 70 candle-feet per pound of coal is about what was generally obtained. It is about what is generally attained in most of the Gas Works near Boston. Also so far as I can find out the Charlestown Co. is the only one in Massachusetts which makes such a coal gas that it can send it out in Massachusetts without enrichment. At the Meetings of the Guild of Gas Managers which are held once a month, the difficulty of getting a gas in pure coal gas works which would be above the 16 candle-power required was often the topic of debate.

The relative advantages of oil and benzol were discussed and the difficulties attendant on the use of each were stated. I stated that it was entirely unnecessary to use either, for I was not reticent about the results we were getting. My statements were met by smiles of incredulity.

In the latter part of 1906 we went on to machine charging and pushing, and in May, 1907, we put in another station meter; so that from that time our results have been determined exactly.

During the last year, from July 1, 1908, to June 30, 1909, we have been running six hour charges of about 1125 lbs. each and the average yield and candle-power as found at the works have been 5.04 (corrected) and 17.25 or 86.94 candle-feet per pound. This is for the whole year. Such benches as these which ought to make 180,000 ft. per day are a very large unit for a Co. whose maximum monthly average is only one million, and its minimum about 560 thousand feet per day. Half the time the benches cannot be run to their full efficiency.

During February, 1909, however, our results were:

Yield (corrected)	5.24
Candle-power	17.32
Candle-feet per lb.	90.76

We have no facilities for taking the temperature of the arches and retorts, but a test taken for an outside party showed an average of 2422 degrees F. between the two bot-

tom retorts, and 2346 degrees between the two just above them. The average temperature inside the retorts was 1928 degrees. A later test gave an average temperature of 2374 between the bottom retorts and 2199 between the two just above them.

The temperature of the gas was taken as follows:

Time	One foot above mouthpiece	Bridge pipe	Gas leaving hydraulic main
10.20	805	440	212
11.05	790	420	196
12.45	660	330	188
2.	850	600	260
3.	...	540	204
3.10	...	...	250
3.45	775	500	196
5.	725	480	240
Average	767°	473°	218°

An analysis of the gas made by the State Gas Inspector is as follows:

Illum.	4.91	by volume
CH_4	33.55	
H_2	51.21	
CO	8.05	
N_2	.97	
O_2	.10	
CO_2	1.21	

Candle-power 17.9 with Sugg's new D. burner and 7″ chimney.

On another day the specific gravity was found to be .451. The calorific value of the gas has not been taken, but it is evidently high.

Neither our yield nor our candle-power has been improved by the adoption of heavy six hour charges instead of light four hour charges. Four hour charges we cannot push, and

the labor involved is somewhat greater than for six hour charges; also the coke is not as good; but we used to get just as much and just as good gas as we are now getting from the six hour charges.

With our little furnaces holding such a small amount of fuel it is an impossibility to maintain an even heat in the benches, such as is demanded for the attainment of the best results. Our average heats are not high, no higher than they were in our old plant; consequently, I cannot believe that the difference in our results is due to the treatment of the coal in the retorts. I believe it is due to the treatment of the gas after it leaves the retort, but I have not proved it. When running efficiently our mouthpieces are dry and so are the standpipes. We do not average one stopped standpipe per month per bench. It is a queer condition. We have the old fashioned, simple, half-depth furnace doing work nearly half as much again as it is usually called upon to do, and day by day and year by year, we are making a better gas than almost anyone else, though the yield per pound may be exceeded: But for a company without a Water Gas Plant we make a thoroughly utilizable gas, which gives satisfaction to our consumers both as a light and heat-giving commodity. I am now building three additional benches which will have but one furnace for each bench of 8 retorts, 20 feet long, and which will have 10 inch standpipes and cross connections. I hope that the larger furnace will enable us to carry more even heats, so that our production will be increased without any sacrifice of the candle-power. My ground for the hope is that as a general thing the high yields are accompanied by high-candle power. This isn't true every day, but, taking the general run of works, the higher the yield the better the candle-power. The idea that the making of an extra half foot of gas would lower the candle-power of the total make has been proved to be entirely false in our case. I can only express my regret that I cannot tell the Institute just why this is so.

For bringing coal from the coal shed into the retort house,

charging it in the retort, pushing the coke out, conveying it out of the retort house, elevating it 60 ft., and crushing what is required, we use one and one-third K. W. hours per ton of coal.

THE CHAIRMAN: Mr. Taussig.

MR. TAUSSIG: I think one of the most notable features of the Worcester plant is the furnaces; being able to run a coal gas bench, and have absolutely uniform heats all through the 24 hours, month in and month out, is a very great advantage to any coal gas man, and I think the sooner the coal gas industry adopts the return of the CO_2 to the bottom of the grates the better it will be for it. One of the great advantages is the lowering of the temperature in the combustion chamber and still putting a large quantity of heat through the retort chamber. To think that Worcester can run 2000 degrees in the retorts with 2400 and a fraction degrees in the combustion chamber is marvelous. I think there are very few plants with full-depth benches that do not run as high as 2600 degrees in the combustion chamber, and then they have a very inferior heat up through the stack. The reason for this, as you all probably know, is that the flame temperature is lowered by the heavy increase of nitrogen, and still the total heat sent through the bench is just as great. I think it is of very great value to the gas industry, in general, to have such furnaces.

Speaking of the material, such a material as used in the Worcester plant, which is a very high Silica brick, is impossible in an ordinary coal gas setting. You cannot for a minute run the ordinary coal gas setting, where the fires are frequently clinkered, with this Silica brick. It expands, in the first place, a quarter of an inch to a foot, which is an excessive expansion. Imagine the changes of temperature, with poor clinkering and poor fires in an ordinary coal gas setting; and yet this material, kept at a constant temperature as it is in the Worcester settings, will last a long time, and has considerably higher conductivity.

Another feature I think is the filling of the retort. I think the fuller you can get the retort, the better, and I attribute much of the high results, as far as the candle-feet at Worcester are concerned, to the fact that he has filled his retorts and been able to get his gas out quickly. It is very probable that a great deal of the gas does not go up through the coal, because his picture indicates that a good deal of gas went along the core of the coke. In our vertical retorts, no matter whether using broken coal or slack coal, we have proved conclusively in our works at Manchester that the gas goes right up through the middle of the coke. You can see it going out through the core of that coke; at times you can put a rod just in the middle of the core, and there will be a regular fountain of gas coming up. There is some back pressure in these vertical retorts.

Now, as to these vertical retorts there is a great discrepancy in yields compared with the yields at Worcester. Part of this discrepancy may possibly be due to slight leaks in the retorts. We had five different retorts of different sizes, and these retorts were connected up in pairs, 3 in one row, and 2 in another. In order to get a uniform candle-power, we had to charge them at intervals, so that the rich gas would mix with the poor; otherwise we would have a very rich gas at first, the candle-power would be 20 candle-power and go down towards the end of the charge. So a yield of 4.82 is not, by any means, a fair example of the yields of vertical retorts. In Germany they get almost as high yields as Mr. Lamson has obtained with his horizontal retorts—I do not know that they have gotten quite as high, but then they have a very much poorer coal.

There is one point to be demonstrated with these vertical retorts, that it is possible to make a high candle-power. Mr. Lamson's candle-powers were taken with an Argand burner. The answers by the Bureau of Information were very carefully made up, as I know, for I know who made them, and there is about 4 candle-power difference between the results

with a Sugg D. Argand and a Flat Flame burner. Now, if you should add 4 candle-power to 16, as we got at Manchester, and make 20 candle-power gas, and multiply that by approximately 5, you would have about 100 candle-feet, which in candle-feet is very nearly the same.

There is one point to be demonstrated that I think is very interesting. Last year I mentioned that we left a space on top of the coal, in order that the tar vapors could be fixed after they left the coal. To my mind it was an ideal way of carbonizing coal; every foot of gas that went up through that retort had to go between 3 and 4 feet of fixing surface, and every foot was treated exactly alike. I have always maintained that you could get high candle-power with vertical retorts, if you treated the gas so as to make Benzol vapors. We had a high candle-power, it was hard to believe it was not over 20, compared with ordinary water gas flame, and I think most of this was due entirely to the effect of this fixing surface. We can regulate the fixing surface to any height we want, and we ought to be able in that way to get the highest candle-feet possible in coal, with a well-designed setting. In Europe, where they have parallel stacks of verticals and horizontals, they always state that they get higher candle-power with the horizontal, and they have shown that there is one to two candle-power difference, but in Europe they fill their retorts up to the top; the gas we know comes out cold; they take pyrometer tests right over the coal, and we know the gas does not reach any temperature sufficient to make much benzol vapors; therefore, they get a high heating value, but they don't get the benefit of the enriching work of the benzol vapors. We in the East have to make candle-power in most cases and it is a very important item. Of course, under such conditions we cannot afford to fill our retorts up to the top.

THE CHAIRMAN: Mr. Brown.

MR. R. B. BROWN: I think, in discussing this paper, some of you gentlemen have forgotten entirely the very thoroughly worked-out mechanical details of this plant. Of course, as

far as the results obtained from the pound of coal is concerned, those mechanical details may not have much effect, but they certainly will show up in the cost of operation and in the maintenance.

As to the furnace operation I agree very closely with Mr. Taussig, that uniformity in heats and the ability to obtain a uniform temperature approaching 2000 degrees inside the retorts, with a quite moderate temperature in the combustion chamber, is a great advantage in a setting. But I want to tell Mr. Taussig and the rest of you that he is absolutely wrong when he says that you cannot use this material in an ordinary bench. In Milwaukee we have had under operation for about 4 years a bench which was designed on very similar lines to these benches, and with the identical material. We were told by the manufacturers that it could not be worked up and down as to temperature without destroying it; so we attempted to destroy it, and we have had it down cold more than ten times—I think it has been cold 12 times in 4 years, and last summer during 4 months it was down to a temperature of under 1500 degrees 27 times. In that bench we have not lost a retort. We have lost 3 or 4 sections by cracking and dropping out. It is very easy to replace them, and we have had no trouble in doing so, but the amount of punishment that bench has had would have put many old-time clay block and retort benches out of business. If you use that class of material, with decent care, it will stand up.

The question of chemical results from the distillation of coal is certainly largely one of temperature, and while at Worcester they are burning large charges, and their retort temperatures are high, I want particularly to call attention to the fact that their gas temperatures are low. They fill the retorts almost full. There isn't any gas space left. The gas comes out of the retort without being subjected to the destructive breaking-down effects of extremely high temperatures, and I think that we must figure that many of the remarkable results obtained there in the chemical character of the gas,

its composition and the quantities of certain constituents and their preservation, are due to the temperature conditions.

Carrying the gas out in that way has had another effect, which perhaps was unexpected, and that is the way the standpipe troubles have been eliminated. They are practically gone; in fact, they are actually covering their standpipes with non-conducting material to maintain the temperatures of the hydraulic main, and some of the older gas men who saw that experiment tried 15 or 18 years ago, I think, will remember that it absolutely killed their operation, that it put their standpipes out of use, and they had to abandon the idea. Now, certainly we have not got the same conditions here; we are using practically the same coal, and we are getting an entirely different character of gas, and the whole difference in the operation appears to be in this question of standpipe temperatures, in other words, of the temperatures of the gas coming off.

There is another fact which I think Mr. Wheeler mentioned, but it must not be forgotten, that you cannot let a retort house run itself and it cannot be run without the closest attention to get such results. A good part of the actual quantitative results in a retort house are due, I am satisfied, to the minute care with which the small details of carbonization are carried out, and I think that is a lesson for all of us. I do not believe there is a man in this room who could not go back to his retort house today and get better results, if he will exercise such care in the small details of carbonization as is exercised at Worcester. But all cannot get the results they are getting at Worcester without some changes in their equipment, but they might get better results than they are actually getting today if they will use more care in the operation. I do not think we ought to let this thing go without emphasizing that fact, that they do look after the little things in Worcester, and I do not know any reason why, with an organization properly perfected, that this cannot be done by everybody to some extent. After such a method is once put into operation

and after your men are once trained, it does not require so much care, but it does require actual knowledge of what you are doing, and keeping right after your men to keep results up to the point that you have once reached.

Mr. Kennedy:—I have seen the Worcester works, and am very pleased to have been able to do so, but I want to say that, in addition to the many things brought forward, one thing has been overlooked, that is the scoop. I do not believe there is any scoop made today that will lay a full charge in a retort as evenly as the scoop that is used at Worcester. We have for 2 years been working with a charge which is absolutely as much as we can get in the retort. It works out practically 60 lbs. per running foot. We have worked on that basis for 2 years, and that is practically the same as Worcester is working today, on the same size of retort. We find that where the yield was formerly probably 4.98 to 4.93 of 15½ candle-gas, the yield for the last month is 5.27 of 15.8 gas. We have brought our yields and candle-feet up until for several days of a period, with high heats, we have maintained 95 candle-feet. We have right along practically 84 candle-feet, but I think it is essential that the coal be loaded in the retort practically even, following as closely as possible the suggestions in Mr. Lamson's paper. I find that there is no charging machine other than the scoop machine that can do it. Our machine is a De Brouwer machine, and with all due deference to the machine, which is a good and cheap machine to operate, there come times, due to the slackening of the belt, or changing in the size of the coal, when you cannot get a perfectly even charge, and we have found that we had to allow 2 inches to take care of that discrepancy in the level of the fuel. If we could correct that, we could get a perfectly even charge.

Another thing, I think the thickness of our front walls in modern settings is too little. We have thickened our walls by from 14″ to 18″. Since we have done this we have had practically no standpipe troubles, whereas we did have serious trouble 2 years ago.

Mr. C. J. R. Humphreys: Mr. President, I will speak a little of the plant we have put in at Lawrence, but before doing so I wish to express my appreciation of Mr. Lamson's paper. I have had the privilege of seeing the Worcester works since the new plant has been put into operation, and it is certainly very interesting in many ways. I think that what impresses one the most on entering the house is what I might call its airiness; the house is so large, and the proportions are so big in every way that it is a very comfortable house to go through and must be a very comfortable house to work in.

I want to say that I consented very reluctantly to speak of our Lawrence plant today—because I am not in a position to give results, and I therefore feel that what I can say is of little practical value. In a general way I will say that we have been putting in complete coal handling and coke handling apparatus, charging machinery, drawing machinery, and pushing machinery, and a series of 6 benches of 8 retorts to the bench. The arches are 8 ft. wide, the retorts are 15″ x 26″ and 20′ long. The benches are heated by one furnace, that is placed on the discharging end. The furnace used is one of my own design that I used for a good many years in connection with the ordinary retorts; it is an outside furnace, and I suppose the only peculiarity about the furnace itself is that it is not rectangular as many furnaces are and as almost all were at the time I designed this furnace. It is more on the plan of an oval, and my idea in designing the furnace that way at the time was because I felt that in a rectangular furnace there was a chance for the coal not backing into the corners and making opportunity for air to come up through the coke bed. The depth of the furnace, I think, is about 6 ft. The problem I had to consider at the outset was whether I could heat these 20′ retorts uniformly with one furnace. I can say now that we have accomplished in that regard all that I expected. We can heat the retorts evenly with the one furnace. The reason that I cannot give any results today is due to the fact that we are not yet perfectly under way:

therefore, I cannot tell you anything about candle-feet or what yield we get. It is for that reason that I was very reluctant to say anything. At present we are only running 5 benches, and we do not need to push the benches, as we make a large percentage of water gas, so that we are running about 21,000 ft. to the retort. The candle-power has been running about 17.3

THE CHAIRMAN: In this paper I am surprised to see that there is so much free carbon in the tar as is shown. We shall have to pass on now to Mr. Jones' paper on

THE DEVELOPMENT OF OIL GAS IN CALIFORNIA.

MR. EDW. C. JONES: Mr. President and Gentlemen—When Mr. Pritchard invited me to write a paper for this meeting on the subject of oil gas in California I hesitated, knowing that it would, at the best, be irrelevant to the gas industries of the East. The subject of oil gas in California is extremely vital to us, however. We have had thrust upon us conditions which we had to meet and make the best of, that is, a large quantity of cheap oil. I have prepared a very careful and rather long paper, descriptive of the development of oil gas in California, and I presume that all of the gentlemen who care to know anything about the subject have read this paper; therefore, I will not read it.

I should like to call your attention to the physical and chemical changes that have been brought about through careful and studious experimenting on the Coast in the production of oil gas.

We have succeeded in producing a gas containing very much less hydrogen than the original oil gas. Our original gas as first made contained as high as 66 per cent. of hydrogen. We have succeeded in reducing that hydrogen content to less than 50 per cent. If there is 50 per cent. of hydrogen in the oil gas or more, the specific gravity of the gas is 0.4 or less; if there is 50 per cent. of the hydrogen in the finished gas or less, the specific gravity of the gas is 0.4 or more, so that we have raised the specific gravity of California oil gas from

an unsatisfactory point, (we will say 0.365) to over 0.45. Our only residual, lampblack, is taken from the gas in the washing box; it is washed out by water and is briquetted or used as lampblack and made into water gas. This admixture of water gas increases the carbon monoxide content from about 5 per cent. to 11 per cent., within the choice of the gas-maker.

There is a comfort in making oil gas, granted that we have cheap oil; that is the convenience of the manufacture, the absolute ability to control labor conditions, and the safety in operating with a small holder capacity, from which I know a great many of you have suffered on account of lack of capital to build big holders. In the city of San Francisco we have had just a few troubles, as you know— shivers of the earth, fires and so on, destroying some gas-holders which could not be replaced in a few minutes. With a bank of oil gas generators, each capable of making 150,000 cu. ft. of gas per hour, and some machines crowded to four million cu. ft. per day each, we have been able to get along with as low as 12 or 14 per cent. of holder capacity. Last winter our holder capacity was 30 per cent. of a 15,000,000 peak output. In some of the California towns under my management we now have as low as 16 per cent. of holder capacity, and it does not worry us a bit.

I have heard a great deal about the use of coal tar for treating roads, and it seems to me that if we had that coal tar out in California, we would make gas out of it. I believe it is possible in modern oil gas apparatus. We are in the gas business, not that of selling tar. If we make tar, we find out why it is; if we make lampblack we use it for making water gas, and we have nothing but gas for sale. I had to buy a barrel of paint the other day to paint a stack. Lampblack, once a nuisance, which in its pasty, nasty form simply brought out suggestions from our friends that we would handle it in such and such a belt conveyor, or that we would pass it through a sieve of cheesecloth or iron mesh, is now handled with a locomotive crane and grab bucket, a clam shell bucket

which will pick up a half to three-quarters of a cubic yard at a time and put it where we want it. We have invented a briquetting press to make briquettes like the sample I have for your inspection. In that briquette at the present moment there is probably between 18 and 20 per cent. of moisture, yet it feels perfectly dry to the touch. But we found that we were wasting money in making briquettes. We stack our lampblack with that locomotive crane, we let it drain by gravity, and after the water has run away from it until its water content is about 20 per cent., we dig into it as though it was a pile of anthracite coal, we put it into our water gas generators on specially prepared but not patented grates, blast it with about 9″ of air pressure and make water gas. The use of water gas in connection with oil gas gives us a check on our candle-power and on everything else that is required or desired by the gas consumer. With a water gas auxiliary we can use our lampblack residual. We can also regulate our candle-power, because we can get the volume of gas from our oil gas apparatus, and build up our candle-power from the water gas side. We have made coke out of the lampblack, but we found we were wasting our money. Coke is very desirable, and lampblack itself is coke. There is none better, only it is in such small particles, that we do not recognize it as coke. But lampblack retorted, as you would retort coal, contains 98.8 per cent. of carbon. The remainder is a very small amount of sodium chloride, due to the scrubbing with salt water. We live out of doors in California, and we make our gas out of doors, we treat it out of doors, and when we have naphthalene troubles in California, instead of looking about for some method of punching a hole through it, and getting the gas to the consumer, we go to our works and find out why it is being made. In every case we find that there is a hole through our checkerwork somewhere; that there is a by-pass; that we are flooding our machines and the oil is being abused instead of being made into gas. By a little change, which may take a few hours, we get the

machine back into working order, and everything goes along smoothly. Of course, it is necessary for the engineer of the company to have a card passed over his desk every morning, showing the total number of complaints and their cause.

THE DEVELOPMENT OF OIL GAS IN CALIFORNIA.

The various methods of distilling oil into gas in externally heated vessels date back to the discovery of petroleum. In nearly all of these processes the oil was subjected to a comparatively low temperature in either iron or clay retorts, with unsatisfactory results attended by much trouble. Not until the introduction of generators and superheaters for water gas making was it attempted to decompose oil in contact with highly heated surfaces of refractory material in internally heated vessels. Then the oil was looked upon as an enricher of other gases, and subservient to these diluent gases which took the name of water gas. The name of oil gas with its unctuous suggestion is apt to awaken unpleasant memories in the minds of the older generation of gas men, who experimented with the many ways of stewing oil in iron retorts. For this reason oil gas as well as water gas is badly named. The oil gas of California is so much like enriched coal gas that no chemist could identify it as having been made from oil.

The high price and scarcity of petroleum in the populous and large gas producing districts of the United States has probably deferred the invention and use of oil gas apparatus until the discovery of vast quantities of oil in California made it an economic necessity. The full extent of this necessity and the reasons for completely changing the method of making gas in California, and abandoning all other generating apparatus will be better understood by referring to the following table showing the quantity and value of petroleum produced in the state during the past twenty-one years, and a chart showing the relation of quantity to value.

PRODUCTION OF PETROLEUM IN CALIFORNIA.

	Quantity, bbls.	Value	Value per bbl.
1887	678,572	$1,357,144	$2.00
1888	690,333	1,380,666	2.00
1889	303,220	368,048	1.21
1890	307,360	384,200	1.25
1891	323,600	401,264	1.24
1892	385,049	561,333	1.45
1893	470,179	608,092	1.29
1894	783,078	1,064,521	1.35
1895	1,245,339	1,000,235	.803
1896	1,257,780	1,180,793	.90
1897	1,911,569	1,918,269	1.00
1898	2,249,088	2,376,420	1.05
1899	2,677,875	2,660,793	.99
1900	4,329,950	4,152,928	.95
1901	7,710,315	2,961,102	.38
1902	14,356,910	4,692,189	.32
1903	24,340,839	7,313,271	.30
1904	29,736,003	8,317,809	.27
1905	34,275,701	9,007,820	.26
1906	32,624,000	9,238,020	.28
1907.	40,311,171	16,783,943	.41
1908	48,306,910	26,566,181	.54

Until 1884 coal gas was made exclusively in California from coals brought from Australia (as ballast for English wheat carrying ships), and the coals from the State of Washington and Vancouver Island. The finding of oil in considerable quantities encouraged the making of water gas as an auxiliary to coal gas, so that in 1899 there were in California:—

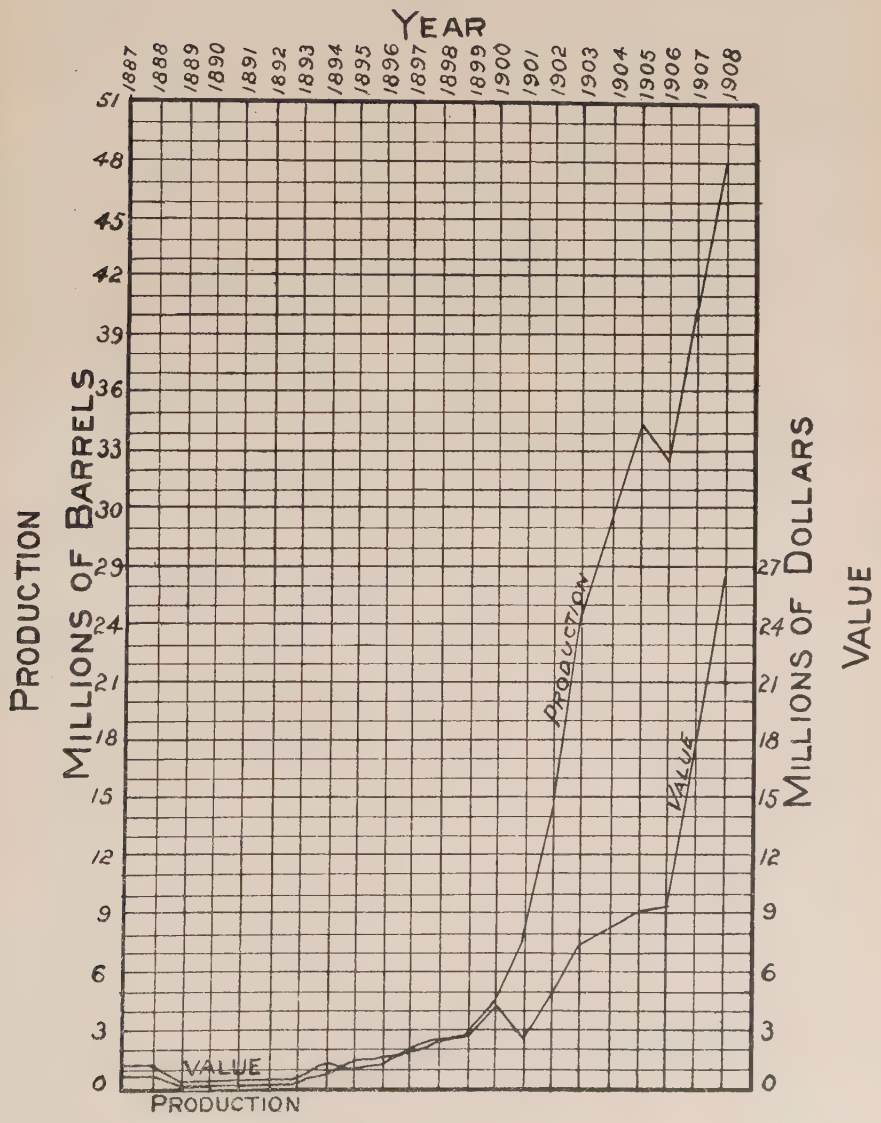
1 Crude Oil Water Gas Works.

10 (Lowe) Carburetted Water Gas Works.

18 Coal Gas Works.

5 Oil and Air Gas Works.

Yearly Production and Value of Petroleum in California



This was the beginning of oil gas making and during that year 2,677,875 barrels of petroleum was produced in the state. For some years after this the production of oil doubled each succeeding year, and the difficulty of finding a profitable market for this enormous increase caused a corresponding drop in the price of oil. This was the incentive for displacing all other crude material for gas making, by oil.

To-day there are in California 56 oil gas works, and in connection with these are three plants for manufacturing water gas from the lampblack residual of oil gas making; 1 small coal gas works, and 1 oil and air gas plant.

The amount of petroleum produced in California during 1908 was 48,306,910 barrels.

The credit for discovering this new method of making gas and the invention of suitable apparatus for use in making it, belongs to Mr. L. P. Lowe, of San Francisco, who anticipated the eventual use of oil gas long before the plentiful supply of cheap oil warranted its commercial use on a large scale. He constructed several small plants in different parts of the state, and September 1, 1902, completed the erection and started an oil gas plant in the works of the California Gas and Electric Corporation in Oakland. This was the first adaptation of the new process to the supply of gas to a large city, and was the basis of experiments from which the present oil gas apparatus has developed. Improvements made it possible to supply the entire output of Oakland September 11, 1904.

The first type of oil gas apparatus was constructed with the idea that extremely high heats for decomposing the oil produced the best results. It is, of course, understood that a generating apparatus consists of two or more shells filled with checker brick, and as there is no solid fuel used, there is an absence of fire boxes and grate bars found in the ordinary water gas generators. The checker brick are heated by oil injected under pressure with steam in company with a blast of air for combustion. No secondary air was used in

the first types of apparatus, and it was quite impossible to control the heat in different parts of the machine. The oil for heating was usually injected at the bottom of the generator under an arch or series of arches.

There is a temptation to use arches in oil gas generators over the combustion chambers for supporting checker brick, but it was soon discovered that no arch can be constructed that will withstand the blow-pipe effect of the oil flame, and the most carefully constructed arches made of the best material obtainable lasted but a few days, or weeks.

It was at first supposed that burning oil in a primary shell and passing the products of combustion over checker brick in a second shell without the use of secondary air coated the checker brick in the second shell with particles of lampblack deposited from the decomposed oil, and that during the succeeding run the steam admitted with the oil for gas making was converted into carbonic oxide and hydrogen in contact with these lampblack-coated surfaces.

The high temperatures at first employed destroyed a large quantity of oil, resulting in a diminished yield of gas of but low candle-power, and the production of a large amount of lampblack. The yield of lampblack amounting to over 30 pounds per thousand cubic feet of gas made. As this lampblack was the result of decomposed hydrocarbons, the hydrogen which had been linked to this carbon remained in the gas as free hydrogen.

Following is an analysis of early oil gas:—

Heavy hydrocarbons	6.2
Marsh gas	25.6
Hydrogen	62.4
Carbonic oxide	3.0
Carbonic acid gas	0.2
Oxygen	0.4
Residual nitrogen	2.2
	100.0

Specific gravity, .303.

Net British Thermal Units, 624 per cubic ft.

The candle-power was 18.6. This gas was made in Oakland, California, in September, 1902, and is a fair sample of the oil gas of those days, which was produced in very highly heated generators with no means of regulating the heat, without wasting it. This gas burned through an open tip had every appearance of coal gas of the same candle-power, the flame being of the same size, but of apparently greater brilliance than coal gas. The small percentage of carbonic oxide is good evidence that little or none of the steam admitted with the oil was decomposed. This is borne out by the fact that carbonic acid gas was 0.2% and as the gas was purified by oxide of iron none of the carbonic acid was removed by purification.

The low specific gravity .303 is, of course, due to the large percentage of hydrogen, and it is undesirable for the reason that there is a greater waste in use by consumers, and the increase of street main leakage is noticeable.

The specific gravity and hydrogen content bear so close relationship to each other that all oil gas containing 50 per cent. or over of hydrogen is of a specific gravity of .4, or under, and oil gas containing less than 50 per cent. of hydrogen has a specific gravity of .4, or over.

The high temperature in the generators created troubles about the same character and disagreeable qualities as those encountered where extreme high temperatures are used in regenerative coal gas benches.

Tar which under other conditions would have passed over to the scrubbers and been condensed in the ordinary way was made into pitch, which mingled with the particles of lampblack, formed solid stoppages in the wash-box, so that it was no uncommon experience to make gas twenty hours one day, devoting four hours to cleaning the wash-box and down-take pipe, while on the following day twenty hours would be devoted to cleaning the wash-box, with four hours' time remaining for gas making. The lampblack recovered as a by-product was made in such large quantities that after a generous amount of it had been used for firing boilers about

the works, there remained a sufficient quantity to become a nuisance.

The lampblack as it is removed from the separators contains from 50 to 60 per cent. of water, and it is necessary to drain off the water until the water content is reduced to about 30 per cent. before the material is fit to be used as boiler fuel. The larger amount of water in the lampblack prohibits the use of any of the briquetting presses that are successfully used for briquetting other dry materials, or materials containing a small amount of binder.

To add to the discomforts of making gas in this way, the wash-box was so constructed that it retained a large amount of lampblack within itself, while the lampblack separator permitted large quantities of lampblack to overflow and be wasted. This waste was not deplored so much on account of the loss in money as from the fact that the drainage from the gas works was usually emptied into a river or bay, and the State Fish Commission complained of the pollution of the water. With these discouragements, and the meager amount of knowledge of the work actually being done, the construction of oil gas apparatus in large units for the supply of gas to cities to the exclusion of all other kinds of gas seemed dangerous and the task was unattractive.

Oil gas machinery had been constructed of all kinds and sizes with hardly two alike, and it first was necessary to design an apparatus applicable to both large and small works, and standardize every detail of it, thus accomplishing in three years the same results that have required thirty years of hard work with water gas apparatus.

The first important improvement was the eliminating of brick arches over the combustion chamber, and the substitution of corbel work at the top of both generators in place of arches. To provide a combustion chamber without arches it was necessary to construct a pair of generators in the shape of a letter "U," one leg of the "U" being much longer than the other. The shorter of the two shells is used as a

primary generator and the air blast is admitted downward through the center of the top of this generator.

At first the oil was fed through burners pointing downward through the top of the primary in the same direction as the air, but it was found that better results were obtained by placing the oil burners in a circle around the side of the generator near the bottom of the corbel work, thus injecting the oil at several points around the circle at right angles to the direction of the air. The top of the primary thus becomes a combustion chamber, and there is no sharp impact of oil flame against any part of the brickwork. To assist a proper understanding of the apparatus, a few illustrations have been prepared, these were photographed from working drawings of a modern and satisfactory oil gas set, as well as from apparatus now in operation.

Figure 1 shows the arrangement of primary and secondary generators connecting at the bottom with a throat piece large enough, so that the passage for gas is not constricted. In this illustration the wash-box, which also acts as a hydraulic seal, and two ordinary steel scrubbers provided with wooden trays are shown. The scrubbers are made a part of the illustration to emphasize the importance of ample scrubbing of oil gas.

Figure 2 shows a vertical section of the generators with their linings, and Figure 3 the arrangement of checker brick in the generators.

It will be noticed that the elbows for the admission of air and the outlet for gas are lined with fire brick to protect them from excessive heat.

Figure 4 shows a 16 ft. set with a capacity of 150,000 cubic feet per hour. This is called a 3,000,000 ft. set and it will produce this amount of gas every day in the year and can be forced to over 4,000,000 cubic feet per day. There are now eight of these sets in operation in San Francisco and Oakland.

JONES' OIL GAS SET.

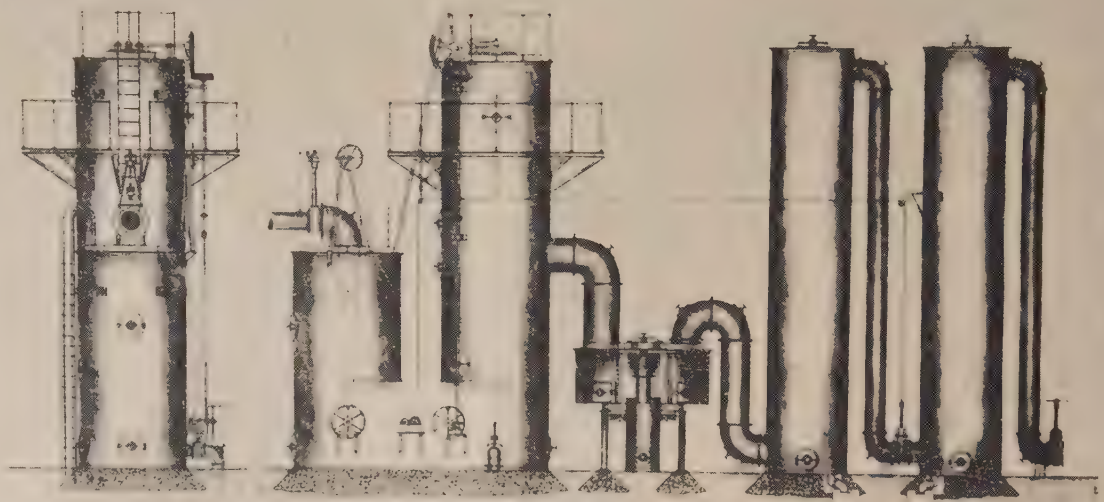


Fig.-1.

Figure 5 is a picture of the operating table between two 16 ft. sets, showing the convenience and simplicity of operation.

The sequence of operations in blasting and making gas, after the brickwork has been brought to a temperature that will ignite petroleum, begins by opening the stack valve at the top of the secondary generator. Opening the air blast at the top of the primary generator and admitting oil and steam through the heating burners at the top of the primary generators. The set is entirely operated from the floor, the gas maker and helper working in unison handling the stack valve, the primary and secondary blast valves, and turning on the oil and steam at the "Oil Table." The oil and steam for heating are admitted through a specially arranged burner shown in Figure 6. Separate coils of pipe encircle the generator, one being for oil, and the other for steam, that for the oil always being at a lower level than the steam coil. This is a precaution to avoid a possible leakage of oil downward into the burners when the apparatus is not in use. Experience has proven that the straight pipe burner with open end gives better results in large sets than any other kind of a burner. Much care, however, has been devoted to the selection of an injector, which will force the oil through the burner into the generator, using steam in the most economical manner. This injector is made of brass, carefully finished, and the oil and steam openings are nicely centered. The straight pipe burner is connected to the shell of the generator through a flange, and on the outside end of the burner is placed a "Y" fitting. The injector is attached to this "Y" fitting, connecting it with the steam and oil pipes. This arrangement does not interfere with the working of the injector, and has the advantage of leaving a straight way for cleaning the burner with a small rod through the plugged end "C," without disturbing the rest of the burner mechanism.

A regulating service cock is placed on the oil inlet and a

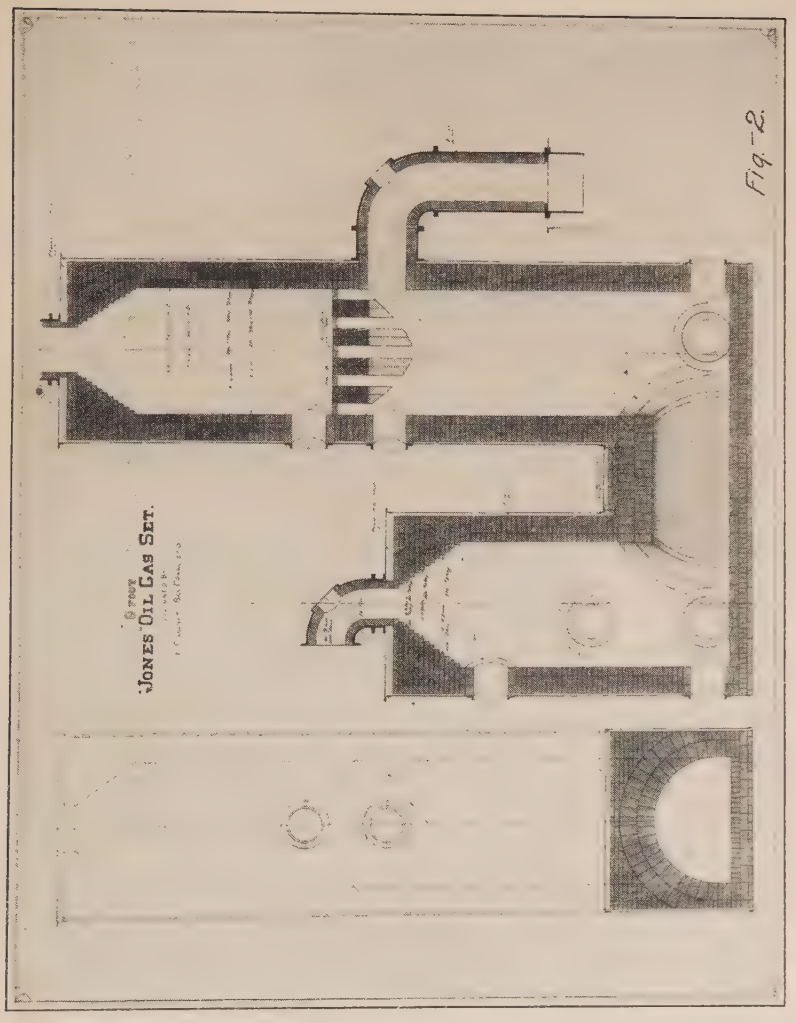


Fig. 2.

standard globe valve "B" on the steam inlet to insure good regulation at the burner. These controlling valves require nice adjustment for the exact proportion of oil and steam, so that when once set the amount of oil and steam used for heating and making is controlled from the oil table.

A glance at the oil table (Fig. 5) shows an oil meter for the heating oil, and one for the oil used for making gas. Gauges are provided for showing the steam pressure at the boiler, and the oil pressure at the outlet of the oil heater. In addition to this there are six nozzle gauges used in connection with each set. Three for steam and three for oil. These gauges are connected to the oil and steam pipe between their respective throttle valves and the machine, so that these gauges practically become steam and oil meters for the guidance of the gas-maker.

The oil table is also provided with thermometers, a jet photometer and test light. The oil is heated to about 150° F. in a tubular oil heater of well known design. There are nine burners for heating at the top of the primary generator. Assuming that the machine has been making gas and a blast is about to begin, and the stack valve has been opened and the air is turned on at the blast valve, no oil is admitted to the machine during the first three minutes of the blast, and the steam on the burners is turned on to a sufficient pressure to keep them clean and protect them against overheating. The blast pressure inside of the primary generator being 9 inches. At the end of the third minute oil is turned into the primary generator at a pressure of 8 pounds inside of the machine while the steam pressure is retained at 35 pounds, and the blast pressure is reduced to 7 inches also within the machine.

The following table shows the progress of the blast on the 16 ft. set.

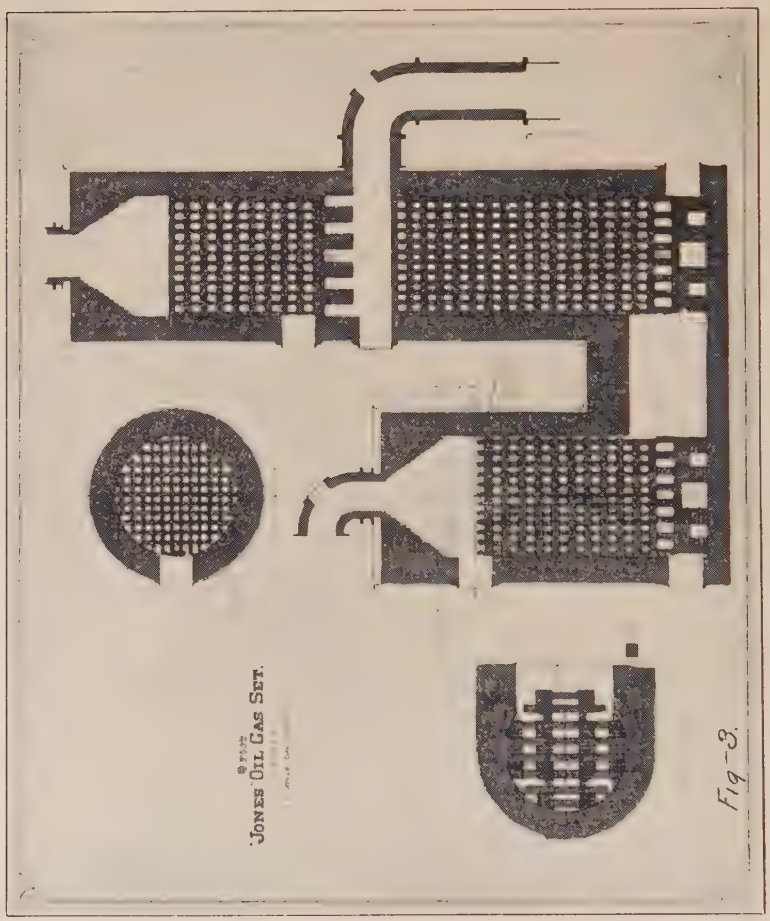
GENERATOR NO. 2 JONES, MONDAY, JULY 26, 1909.

Min.	Oil temp. Fah.	Oil pressure to heat, lbs.	Steam pressure to heat, lbs.	Oil to heat, gallons	Blast pressure, inches.
1st			35	blow	9
2nd			35	blow	9
3rd			35	blow	9
				3.25	
4th	150°	8	35	3.25	7
				3.50	
5th	150	8	35	3.50	7
				3.25	
6th	150	8	35	3.25	7
				3.50	
7th	150	8	35	3.50	7
				3.25	
8th	150	8	35	3.25	7
				3.50	
9th	150	8	35	3.50	7
				3.25	
10th	150	8	35	3.25	7
				3.25	
11th	150	8	35	3.25	7
				3.25	
12th	150	8	35	3.25	7
				60.00	

The duration of the blast in the large machines is 12 minutes. Three minutes without and nine minutes with oil.

At the end of the heat the blast valve is closed and a quick opening valve at the outlet of the first scrubber is opened by means of a winch attached to the generator, and a wire rope running over pulleys to the valve stem. This valve is opened during runs and closed during heats, for the purpose of isolating the set from the rest of the works during the heating

process, and to permit the use of high blast pressure without breaking the seal in the wash-box, thus sending oil producer



gas through the wash-box and scrubbers. As the man on the floor turns off the blast, opens the scrubber valve and closes the stack valve, the gas-maker does not shut off the heating oil, he first turns on the oil and steam to the gas-making burners, which are separate and distinct from the heating burners, and

then shuts off the oil and steam from the heating burners, so that there is no interruption in the making of gas. The heating oil serving for this purpose during the moment necessary for changing the valves. The temperature of the primary and secondary generators is observed by means of sight cocks, the gas-maker becoming very skillful in detecting changes of color in the checker brick and turning on secondary air when the outgoing stack gas has the appearance of containing combustible gas.

In this connection the personal factor represented by the skill of the gas-maker enters more largely into the equation of good results than in either coal or water gas making. For making gas the oil and steam is first turned into the top of the primary, the oil is decomposed by passing downward through the checker brick in the primary generator, thence through the connecting throat piece and up into the secondary generator. Should the gas thus made be permitted to traverse the entire length of the secondary generator to the top the illuminants would be partly decomposed by breaking down into marsh gas, hydrogen and lampblack. To prevent this overheating and protect the gas, the outlet of the machine is placed at or near the middle of the secondary generator. Above this point there is a large amount of heat stored in checker brick placed upon a number of arches, sprung across the generator. These arches are durable, because there is no direct combustion of oil in proximity to them. To make use of the heat in the top of the secondary generator coils of steam and oil pipes are connected with 18 burners in the corbel work at the top of the secondary, 15 of these burners are used for making gas, while three are steam pipes for purging. The gas thus made passes downward and through the side outlet into the wash-box. It will thus be seen that gas is made in two directions, leaving the machine through a common outlet. The reasons for this are obvious.

During the process of heating it is some times difficult to so regulate the temperature in the primary and secondary

generators even if the checker brick in both generators are in equally good condition for breaking up the oil, and if the gas was taken off at the top of the secondary, it would be impossible to so regulate the heat that no oil would be wasted, gas over-heated, or the yield of gas per minute reduced. By adopting the side outlet all heat is conserved, if the top of the secondary is overheated more oil is used in that part of the machine, and if the primary is at too low a temperature less oil is used in the primary. In this way all heat is used for gas making and practically none is wasted, at the same time a uniform quality of gas is maintained.

One of the best indicators of the quality of gas being made is the condition of the overflow water from the wash-box, and first scrubber. The presence of tar in the wash-box seal shows that the heat is too low and lampblack in the overflow from the first scrubber shows that the heat is too high.

The following table shows the amount of oil used in gallons, in different parts of the set, together with the steam and oil pressures, all pressures being on the inner side of the throttle valves and within the machine. These figures were taken from the run after the foregoing heat, the duration of the run was 10 minutes. Oil is admitted to the top of the primary, beginning with 26 gallons per minute and reduced to 9 gallons during the 8th minute. Oil is admitted to the top of the secondary, beginning with 39 gallons, during the first and ending with 12 gallons during the eighth minute. The steam pressure remains constant during 8 minutes of the run. At the end of the 8th minute the oil is shut off from the primary and secondary and the steam pressure on the primary and secondary is raised to 110 pounds, and allowed to remain at this pressure for the last two minutes of the run for the purpose of purging the machine. For purging the machine during the last two minutes of the run three special open steam pipes are used at the top of the secondary, steam is maintained on the burners at the top of the primary and secondary and a one-inch steam pipe admits steam to the

bottom of the primary directly opposite the throat piece, this is also for the purpose of clearing the machine.

MAKE OF GAS, JULY 26, 1909.

Min.	Oil temperature, Fah.	Oil primary gals. to make	Oil secondary gals. to make	Oil pressure primary lbs.	Steam pressure primary lbs.	Oil pressure sec. lbs.	Steam pressure sec. lbs.	Boiler steam pressure lbs.
1	150	26	39	21	25	27	35	110
2	150	26	39	21	25	27	35	110
3	150	18	26	19	25	24	35	110
4	150	18	26	19	25	24	35	110
5	145	18	26	19	25	24	35	110
6	145	17	26	19	25	24	35	110
7	145	17	26	19	25	24	35	110
8	145	9	12	19	25	24	35	110
9	140	purge	purge		110		110	110
10	140	purge	purge		110		110	110

Following are two analyses of gases taken at the stack valve at the middle of the heating period.

JONES SET NO. 2.

Carbonic acid 13.1%
Oxygen 1.9
Nitrogen 85.0

JONES SET NO. 1.

Carbonic acid 15.3%
Oxygen 0.2
Nitrogen 84.5

These analyses are frequently taken to determine the ratio of air to heating oil.

6 per cent. of carbonic acid indicates three times the theoretical amount of air required.

9 per cent. of carbonic acid indicates two times the theoretical amount of air required.

17 per cent. of carbonic acid indicates one times the theoretical amount of air required.

(Experiments at Munich, 1880, Stillman's Engineering Chemistry.)

The following table gives the make of gas per minute for a series of five runs. These were of necessity taken on different days for the reason that the gas was carefully measured in a relief holder isolated for the purpose and careful correc-

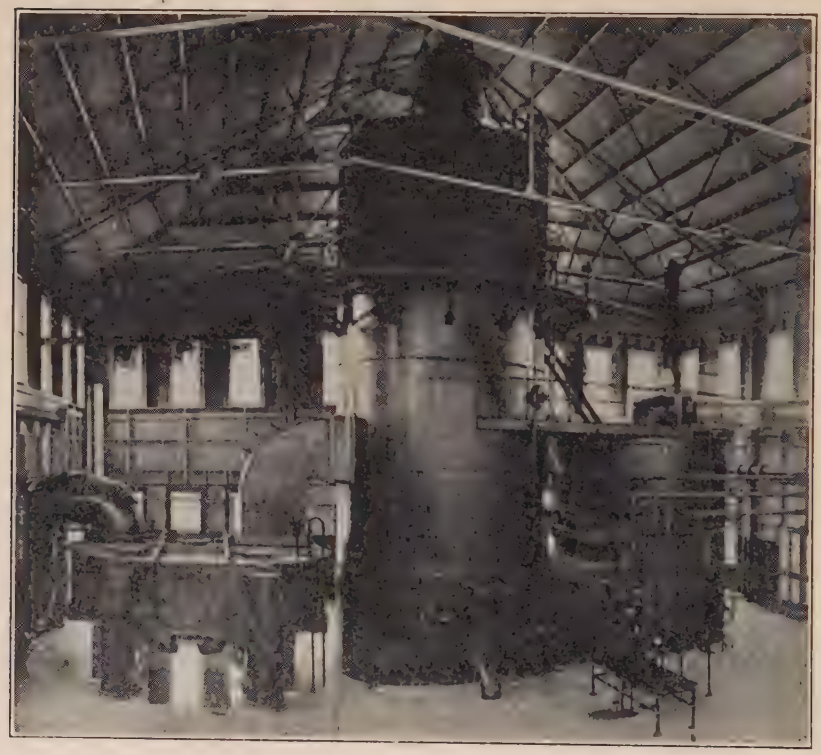


Fig. 4.

tions for temperature were made to avoid error in measurement. The amount of oil used for heating and making, and the total oil used per thousand feet of gas are given in this table. The make of gas per minute during a 10-minute run is a good indication of the application of the heat contained in the checker brick in the making of gas, and an index to the proper length of the run.

Test Runs on No. 2 Jones Set.

Min.	July 9th	July 10th	July 10th	July 12th	July 12th	Average
1st	7,080	6,664	5,206	8,538	7,497	6,997
2nd	6,247	7,705	6,872	6,664	9,371	7,372
3rd	6,039	7,080	7,082	8,333	7,497	7,206
4th	5,831	6,664	6,247	8,225	7,393	6,872
5th	5,623	6,248	6,248	6,248	6,664	6,206
6th	5,623	6,248	6,247	6,351	5,831	6,060
7th	5,415	6,664	6,248	6,559	6,768	6,331
8th	4,790	2,915	4,165	3,748	3,540	3,832
9th	2,707	2,290	2,082	1,978	2,291	2,270
10th	2,082	1,042	2,082	1,874	833	1,583
Totals	51,437	53,520	52,479	58,515	57,685	54,729
	Gals.	Gals.	Gals.	Gals.	Gals.	Gals.
Heat oil	70	70	70	70	70	70
Make oil	370	373	370	370	400	377
Total oil	440	443	440	440	470	447
Oil per "M"	8.55	8.28	8.38	7.53	8.13	8.17

Following is a table giving the analyses of the gas made during a run made on July 9th, 1909. Samples of gas were taken from the wash-box at the end of the second, fifth and seventh minutes, and analyzed.

Analysis of Foregoing Make. Jones Set No. 2.

	End of 2nd min.	End of 5th min.	End of 7th min.
Carbonic acid gas	1.6	0.8	0.4
Illuminants	3.4	6.6	9.0
Oxygen	0.2	0.2	0.0
Carbonic oxide	9.4	8.0	6.6
Hydrogen	53.2	50.6	44.8
Marsh gas	28.5	30.9	35.0
Nitrogen	3.7	2.9	4.2
B. T. U. per cu. ft.	589.	665.	732.
Specific gravity	.382	.391	.423

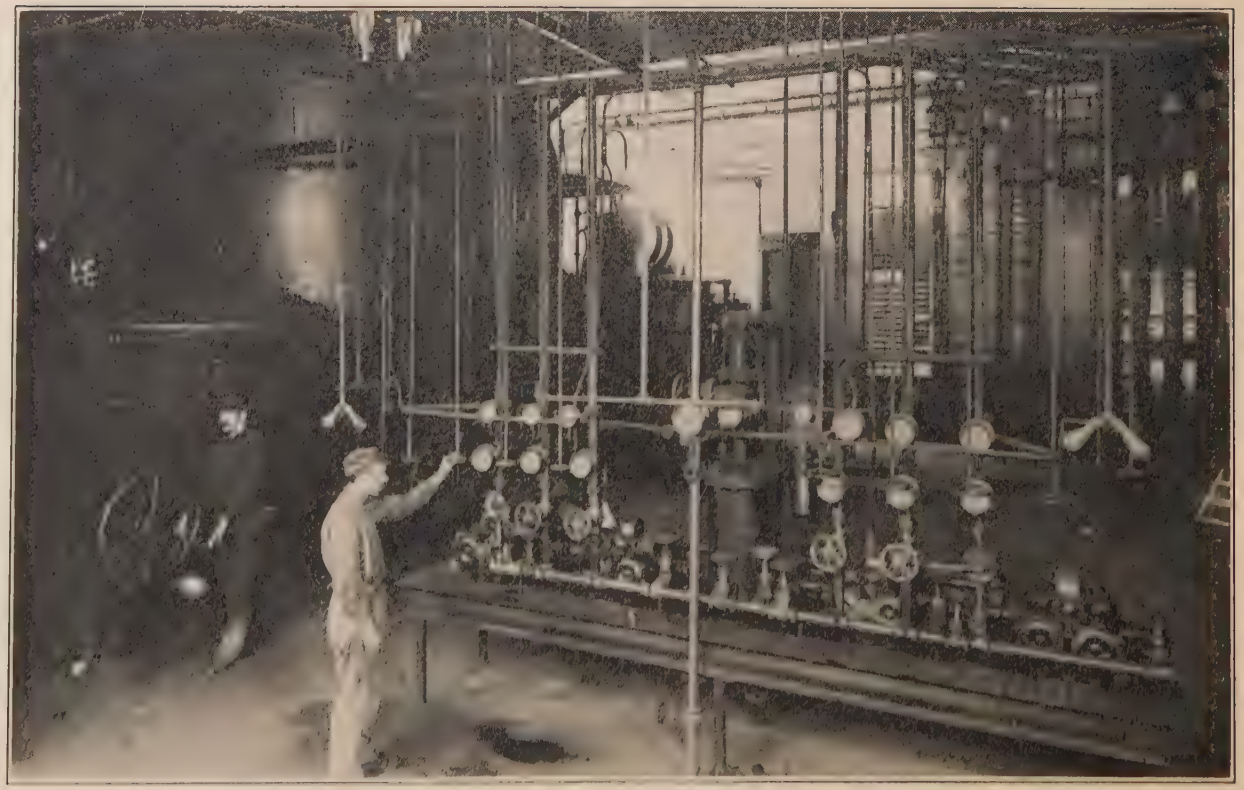


Fig. 5.

Following are the results of a typical run giving the amount of gas made, oil used and an analysis of the gas taken at the outlet of the wash-box during the first minute when all the gas was made in the primary generator, and during the second, fifth, seventh and tenth minutes.

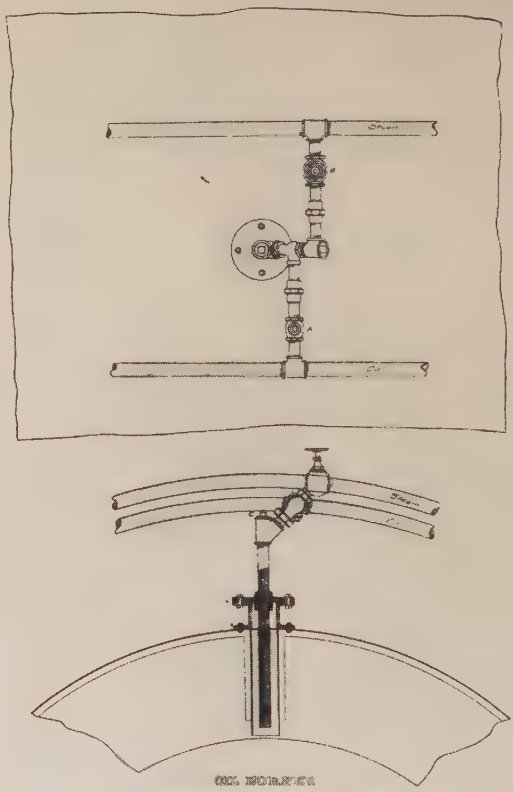
Potrero, June 4, 1909.

Result of analyses of samples taken at outlet of wash-box of No. 3 Jones Set:

	Pri.	2nd	5th	7th	10th
Carbonic acid	1.8	1.3	0.0	0.0	0.0
Illuminants	8.6	2.1	5.0	5.8	7.8
Oxygen	Tr.	Tr	Tr.	Tr.	Tr.
Carbonic oxide	5.6	20.2	9.4	8.2	14.6
Hydrogen	31.7	44.1	46.6	44.9	47.4
Marsh gas	43.4	26.7	35.7	37.3	25.9
Nitrogen	8.9	5.6	3.3	3.8	4.3
B. T. U. .....765.		549.	675.	698.	747.
Specific gravity	.514	.469	.402	.411	.435

Min.		cu. ft.	
1st.		5,625	
2nd.		5,833	
3rd.		6,041	Oil 320 gals. to
4th.		5,625	make, 60 gals.
5th.		5,416	to heat. 380 gal-
6th.		5,000	lons total.
7th.	7½ min. pri. oil off.	4,373	8.25 gallons per
8th.	8th. " sec. " "	4,166	"M" cu. ft.
9th.		3,125	
10th.		833	
	Total	46,041	

The percentage of carbonic oxide in these analyses would lead to the conclusion that the carbonic oxide is not formed by contact of steam and the carbon remaining in the generators after a heat.



"JONES" OIL GAS SET.

DESIGNED BY

F. C. JONES, SAN FRANCISCO

Fig. - 6.

It will be noticed that the gas made in the primary generator at the beginning of the run contains 5.6 per cent. of carbonic oxide, while during the second minute it increases to 20.2 per cent. and then drops to less than half that amount during the 5th and 7th minutes, rising again to 14.6 per cent. during the 10th minute. The carbonic oxide is undoubtedly produced by the dissociation of steam in contact with incandescent particles of lampblack, which have been thrown down by the breaking down of hydrocarbons.

It is now a well understood fact that the oxygen of steam will not unite with carbon in combination with hydrogen, so that neither carbonic acid nor carbonic oxide is generated directly from the hydrocarbons of the oil in contact with steam. It being first necessary to convert the oil into gas or hydrocarbon vapor and then break down the hydrocarbons into lampblack and hydrogen. This lampblack becoming incandescent will unite with oxygen of steam. The high percentage of nitrogen in the primary gas is probably due to the presence of a small amount of products of combustion remaining in the primary generator after the heat. This nitrogen diminishes to the 5th minute and then increases to 4.3 per cent. during the 10th minute.

California petroleum contains over 1 per cent. of nitrogen, usually 1.1 per cent. This is twice the amount of nitrogen contained in the petroleum of Pennsylvania and West Virginia. In distilling California petroleum the third fraction taken off between 200 and 250° C. has a strong odor of ammonia. This ammonia is destroyed in the gas generators at higher temperatures, appearing in the gas as nitrogen and hydrogen.

To further determine the part played by the steam admitted with the oil three runs were made on a 16 ft. set, first in the ordinary way, second with oil injected under its own pressure without steam, and third by steam without the use of any oil. In each case after the generator had been heated ready to make gas.

	Ordinary run	All oil	All Steam
Carbonic acid	0.4	0.4	43.8
Illuminants	5.2	6.2	0.0
Oxygen	0.1	0.1	0.2
Carbonic oxide	7.0	5.3	10.6
Hydrogen	46.6	47.9	5.0
Marsh gas	30.6	36.7	0.0
Nitrogen	5.1	3.4	40.4
Specific gravity	.404	.388	1.168
B. T. U. per cu. ft.	668.302	700.746	53.55

Ordinary Run—Same gauge pressure as combined oil and steam runs. 17″ pressure inside machine, 47 gallons per minute.

All Oil Run—18 lbs. to 19 lbs. oil pressure on primary, 25 lbs. to 27 lbs. oil pressure on secondary. 21″ pressure inside machine, 51 gallons per minute.

All Steam Run—25 lbs. pressure on heat burners.
26 lbs. pressure on primary make burners.
32 lbs. pressure on secondary make burners.
Pressure, machine, 10″ to 11″ (inside.)

The run made with all steam cannot be directly compared with the other two runs, as very little gas was produced, barely enough to enable the taking off of a sample at the wash-box. The generator during this period was at the same temperature as during ordinary runs, that is, at a temperature high enough to decompose steam in the presence of incandescent carbon and only 10.6 per cent. of carbonic oxide was produced. Had there been much carbon deposited on the checker brick this generator would have been in ideal condition for the manufacture of "blue" water gas.

A word in regard to the California petroleum from which this gas is made. The crude petroleum from 12° to 17° B. is best adapted to the purpose of making gas. This oil has an asphaltum base, which is true of most of the petroleum produced in California and this makes it in a measure unattractive

to oil refiners. The oil which was used during the experiments here recorded was 15.8° B. at 60° F. Distillation began at 85° C.

FRACTIONAL DISTILLATION OF CALIFORNIA CRUDE PETROLEUM.

15.8° B. at 60° F.

Distillation begins 85° C.

		Fraction	Color of fraction
No. 1...	Below 150°C.	5.0% 2¼% water	yellowish
" 2...	150°—200°	4.0	yellow
" 3...	200°—250°	27.5	lemon H_2S & NH_3
" 4...	250°—300°	14.0	lemon
" 5...	Above 300°C.	39.5	red
" 6...	Coke	8.0	black
	Loss	2.0	
		100.0	

Flash point, 257° F.

Fire Test, 293° F.

After the 300° fraction comes off the temperature rises immediately to above 380° C.

The ultimate analysis of oil taken from this same field is:—

Carbon	85 %
Nitrogen	1.
Sulphur	.8
Oxygen	1.0
Hydrogen	12.2
	100.0 by weight

The exact amount of sulphur in the oil used for these experiments was 0.93 per cent.

Oil containing sulphur in quantity below one per cent. will produce gas which may be satisfactorily purified by ordinary oxide of iron. Should the percentage of sulphur exceed 1

per cent. purification becomes difficult unless there is large purifying capacity provided for it. Crude oils in California in some instances contain as much as 4 per cent. of sulphur, but it is better not to purchase oils containing so much sulphur than it is to provide elaborate and expensive means for purifying the gas. It is fortunate that the most available crude oils produced in greatest abundance and best adapted to oil gas-making have a small percentage of sulphur. After these crude oils are distilled and the distillates are sold for gas manufacture the distillate contains all of the sulphur of the crude oil condensed into the lesser quantity of distillate. It is the opinion of the writer that a crude petroleum from 14° to 16° B. is the oil which gives the best results in oil gas-making. In other words, the more pounds in weight to the gallon of oil the greater will be the production of gas, and there will be less waste of oil. This is diametrically opposed to good water gas practice, but the conclusion has been reached after use in practice and experimentally of crude oils from 8° B. to 37° B. and distillates from 20° B. to 42° B.

The Wash-Box.—The wash-box serves a double purpose as a hydraulic seal and as a piece of apparatus in which nearly all of the lampblack is separated from the gas and held in suspension in the water. The early forms of wash-boxes were comparatively of small dimensions and were filled with baffle plates and partitions, forming excellent lodging places for lampblack, so that the cleaning of the wash-boxes was an important part of the gas maker's daily work. In the development of a self-cleaning wash-box to take care of the amount of lampblack made by a 16 ft. set it became necessary to depart from the square or circular form and adopt an oval shape, having a superficial area of 265 square feet, also to depart from the usual custom of connecting the generator to the wash-box and the wash-box to the scrubbers with pipe of the same or even smaller diameter than the trunk mains in the gas works. Allowance is made for the expanded condition of the hot gas leaving the generator and in what is known as a 24-inch gas

works the inlet and outlet pipes to the wash-box are 48 inches in diameter, while the diameter of the dip pipe in the wash-box flares to 68 inches. This removes one of the chief causes of back pressure and enables the hot gas to easily get away from the machine.

In the new form of wash-box there are no partitions or diaphragms and the space within the box is clear. The gas enters through a dip pipe at one end and passes out through an outlet pipe from the top of the wash-box at the other end. Two large overflows on the side of the wash-box carry away the lampblack. The self-cleaning principle of this wash-box consists in constant agitation of the water in the box, this is done by dividing the main water supply into a number of one-inch pipes 12 in all, extending to within 3 inches of the bottom of the wash-box. The water is thus forced downward to the bottom of the box and rises to the overflow. The lampblack is washed out of the gas by this turbulent water and is carried out of the box before it has an opportunity to settle. The average temperature of the water entering the wash-box is 61° F., and the average temperature of the water leaving the wash-box is 129° F. The temperature of the gas leaving the wash-box is 142° F., and the amount of water used in the wash-box is 46 gallons per thousand cubic feet of gas. The lampblack and water pass from the wash-box through open drains to the lampblack separator.

Scrubbing.—Thorough scrubbing of oil gas is all important and it has been proven conclusively that it is better to treat oil gas directly with a large quantity of water than to use the methods of condensing and scrubbing as applied to coal gas, where valuable by-products must be removed. Oil gas requires more water for scrubbing than any other kind of gas on account of the finely divided particles of lampblack held in suspension in the gas, and these must be removed, as they would tend to destroy the purifying material, and should the lampblack pass through the purifiers it would cause endless

trouble by stoppages. One uniform kind of scrubber and method of filling it has been adopted. The old style cylinder filled with trays through the top is the best to be had, but the filling should be carefully done. The trays are made of one inch by six inch pine lumber surfaced on four sides and nailed together in sections with spacing pieces 1 inch thick, also made of surfaced lumber. These trays are made in sections small enough to go through a door on the top of the scrubber. Each alternate layer of trays is placed at right angles to the one immediately under it, and the entire shell is filled without voids of any kind. As these trays are made somewhat smaller than the inside diameter of the steel shell in order to provide for easily getting the trays in and out, and for the swelling of the wood, it is essential that the space between the trays and the shell shall be caulked with excelsior, so that the gas cannot pass around the trays instead of through them, or the water flow down on the inside of the shell. In this way the gas is compelled to pass up through the trays, meeting smooth wet surfaces, and the water passes evenly downward through the trays, thus the maximum efficiency is obtained by the use of the smallest amount of water.

Figure 7 shows a plan of a scrubber tray and the arrangement of the trays in the scrubber. In the larger works there are three scrubbers 12 ft. 7 inches in diameter by 40 feet high, and the water is supplied to them through ten sprays passing through the top head. In this connection with each 16 ft. apparatus the amount of water used is approximately 15 gallons per thousand cubic feet of gas per scrubber, or 45 gallons per thousand cubic feet for the complete scrubbing of the gas. Salt water is used in the wash-box and in all scrubbers. It gives satisfactory results, having no deteriorating effect upon the gas, or the scrubbing apparatus. It has the further advantage, where gas works are located on tide water, of being used in abundance at small cost for pumping, and wasted after it has been used. In small plants where water is scarce or expensive, it becomes necessary to be more saving in the

use of water, and in some cases to cool the water and use it over again.

The Lampblack Separator.—The overflow water containing lampblack flows from the wash-box through open, exposed drains into the lampblack separator, and in nearly all oil gas works the overflow water containing tar from the scrubbers

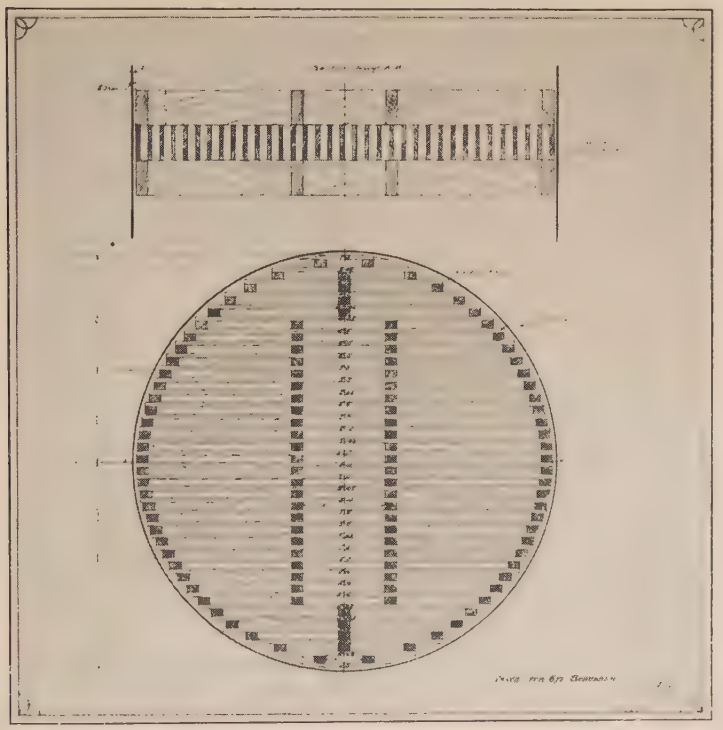


Fig. 7.

flows into the same separator. The amount of tar is so inconsiderable that it is seldom recovered for sale, but mixed with the lampblack it adds somewhat to its fuel value and acts as a binder in briquetting.

Separators of small dimensions and containing many partitions have been superseded by those of much larger dimen-

sions with fewer partitions, experience with the separating of lampblack from water has developed the fact that the greater the area of the separator, and consequent slower speed of flow of water, the more thoroughly is the lampblack separated from the water.

The lampblack and water first empties into a separator provided with a constantly moving skimmer, consisting of pieces of 1 x 3 oak fastened to sprocket chains. The light fluffy lampblack rising to the surface of the water is skimmed off by these scraping pieces and taken through a trough to a height of about 25 feet, and emptied into a settling tank, the walls of which are made of dry lampblack in the form of a crater of a volcano. After this skimming process the water flows into a separator as shown in Figure 8.

This is a picture of a separator recently installed, and capable of separating lampblack from the water used in the manufacture of 12,000,000 feet of gas per day. In this separator there is a single partition running longitudinally; this partition is provided with a skimmer extending below the surface of the water. The separator is made in two sections to enable the alternate cleaning and use of the sections. The water containing lampblack flows into one of the large pits and the separation is accomplished by the settling of the lampblack particles through the water. This is of necessity slow, because the specific gravity of the lampblack is so nearly like that of water. The water passes under the skimmer and over the partitions into the next pit, where further settling takes place; out of this pit the clarified water passes through an open flume and is wasted. When the two pits are filled with lampblack the water gates are opened into the next pair of pits and the water is shut off from the pits filled with lampblack. The removal of the lampblack is then performed by means of a locomotive crane and clam shell bucket. The water-soaked lampblack thus removed is deposited in a pile and allowed to drain. After it has drained until there is about 30 per cent. of water remaining in it, it may be used

Fig. 8.

as boiler fuel. This was the only use to which lampblack was put in the early days of oil gas making and attempts were afterwards made to make briquettes of the substance for domestic use. This proved difficult on account of the large amount of water contained in what seemed to be comparatively dry lampblack, and it was found that the only simple and practicable method of briquetting was by the use of a plunger operated by a crank shaft for forcing the lampblack into an open cylindrical mould, thus forming an endless briquette, after the manner of a sausage machine. These briquettes would break by their own weight in lengths which were multiples of the length of a stroke, that is, if the stroke of the machine is 1½ inches, the briquettes would break off in lengths of 3, 4½, or 6 inches. This method was found to be slow and expensive, and a vertical press was invented which had 4 plungers arranged on one shaft. The lampblack was fed through a trough into 4 moulds and pressed by the plungers into and through these moulds breaking off into pieces in the same manner as described above with a single horizontal press. This vertical press produced 50 tons of briquettes in 24 hours. The briquettes were 3 inches in diameter, weighed 5 4/10 ounces per lineal inch, or 82½ pounds per cubic foot. They are smooth on the outside and possess cohesion enough to permit of ordinary handling. The only binder used in the making of these briquettes was the normal amount of tar flowing from the scrubbers into the lampblack separator. The briquettes were apparently dry when made, but still contained a considerable quantity of water.

Following is an analysis of a briquette after it had been stored for one year in a dry place:—

Moisture	8.5
Volatile matter	10.8
Fixed carbon	79.9
Ash	0.8
	100.0

These briquettes are an ideal fuel, particularly for use in open grates, and owing to the small percentage of ash, the briquettes when once ignited remain at a glowing heat until they are entirely consumed. The only objection to the use of them is the strong odor of naphthalene which they possess, and which does not entirely disappear after storage for a long time.

In order to avoid the inconvenience of dealing in by-products, it was decided to make the experiment of using lampblack briquettes as a substitute for anthracite coal in water gas generators. In a station contiguous to the Potrero plant in San Francisco, there were six sets of double superheater Lowe water gas apparatus, with a rated capacity of 1,000,000 cubic feet each. Briquettes were used in these sets with some success, but the capacity of the sets was reduced 50 per cent. by using lampblack; that is to say, no more than 500,000 cubic ft. of gas could be made in a day with a set rated at 1,000,000 cubic feet. The making of gas in this way, however, had decided advantages, as there was an entire absence of clinker and it required very little time to clean the fires. Contrary to expectations, the air pressure required to blast through lampblack was extremely low, never exceeding 9 inches. The average amount of lampblack used per thousand cubic ft. of gas covering a period of six months was 39.86 pounds, and the oil used for enriching was 6.8 gallons per thousand. This oil was the ordinary 14° to 16° crude oil with asphaltum base. The candle-power ranged from 28 to 33 candles. At that time the gas supplied to San Francisco was 23 candle-power, and the oil gas which was made in the large generators was 19 candle-power, so that the candle-power of the oil gas was raised by mixing about 24 per cent. of the high candle-power lampblack water gas with it.

A typical analysis of the lampblack water gas is as follows:—

Heavy hydrocarbons	16.5
Marsh gas	32.8
Hydrogen	24.6
Carbonic oxide	13.7
Carbonic acid gas	6.2
Oxygen	0.2
Residual nitrogen	6.0
	100.0
Specific gravity	.647
Net British Thermal Units per cu. ft.	814.
Candle-power	28.5

A lampblack fire is apt to flue during the blast and it requires some care to keep the fuel bed in condition, as shown by the amount of carbonic acid in the gas produced.

In using the lampblack the ordinary round grate bars are placed ½ inch apart, and great care is necessary not to overheat the superheater and thus make lampblack in the water gas apparatus. During the heavy demand for gas last winter the use of lampblack exceeded the capacity of the single briquetting press, and it became necessary to use lumps of lampblack dug from the side of a pile of dry material. These lumps were of about the same size as the coarse anthracite coal ordinarily used, and were broken away from the pile with pick axes. It was found that the lumps held their shape fairly well in the generator, and gave fully as good results as briquettes. Lump lampblack was substituted for briquettes in all the generators, thus saving the cost of briquetting and considerably reducing the cost of lampblack water gas.

Following is a recent analysis of the lampblack used in the generators:—

Volatile matter, including moisture	34.15%
Fixed carbon	65.80
Ash	0.05
	100.00%

The first lampblack water gas was made July 14, 1906, and this gas has been made continuously without the use of other fuel in the generators since May 5, 1907.

The improvements in oil gas manufacture described in this paper have made it possible to regulate the amount of lampblack produced so that a combination of oil gas and lampblack water gas plant will produce only enough lampblack for boiler fuel and generator fuel with no product remaining for sale, excepting gas. The amount of lampblack now produced in the largest oil gas sets is 20 pounds per thousand cubic feet of gas.

For the purpose of showing the average composition of oil gas, lampblack water gas, and the mixed gas now made and distributed in San Francisco, the following series of ten analyses each, from June 11th to June 22nd, inclusive, are given. These analyses were taken at random during each of the above dates and the average of these is a good criterion of the composition of the gas.

Analyses of 10 Samples of Crude Oil Gas and Average Analysis.

June	CO_2	C_nH_{2n}	O_2	CO	H_2	CH_4	N_2	C. P.	B. T. U.	Sp. gr.
11	2.5	7.1	0.2	9.2	40.5	33.8	6.7	18.4	675.	.479
12	2.5	7.0	0.2	9.3	37.8	35.8	7.4	22.2	686.	.495
14	2.4	8.0	0.2	9.4	40.0	33.3	6.7	21.2	687.	.485
15	2.8	6.2	Tr.	9.4	39.0	35.4	7.2	18.5	670.	.487
16	2.2	6.8	0.2	8.8	40.1	35.5	6.4	20.8	685.	.474
17	2.4	7.0	0.2	8.4	42.8	34.2	5.0	18.8	683.	.456
18	2.4	7.0	0.2	9.4	38.7	35.1	7.2	18.7	681.	.489
19	3.0	7.2	Tr.	9.8	39.1	34.7	6.2	19.7	684.	.490
21	3.0	6.8	0.4	9.4	40.2	33.5	6.7	18.4	665.	.481
22	3.0	7.0	Tr.	9.0	39.6	35.1	6.3	20.2	683.	.484
Av.	2.62	7.01	0.16	9.21	39.78	34.64	6.58	19.69	679.9	.482

ANALYSES OF 10 SAMPLES OF CARBURETTED WATER GAS AND AVERAGE ANALYSIS.

June	CO_2	CnH_2n	O_2	CO	H_2	CH_4	N_2	C. P. B.	T. U.	Sp.gr.
11	5.6	17.0	0.2	14.0	26.0	31.6	5.6	32.5	816.	.636
12	5.6	16.8	0.2	13.4	23.8	34.7	5.5	32.2	836.	.643
14	5.4	17.0	Tr.	13.6	27.0	32.0	5.0	33.1	822.	.624
15	6.0	17.0	Tr.	13.0	25.6	33.6	4.8	30.5	833.	.633
16	5.6	16.2	Tr.	13.6	24.4	33.4	6.8	29.1	812.	.643
17	5.7	16.3	Tr.	13.2	25.2	33.5	6.1	29.5	817.	.635
18	6.0	16.0	Tr.	13.0	25.3	33.6	6.1	28.3	812.	.636
19	5.8	16.0	Tr.	14.2	24.9	32.0	7.1	28.8	797.	.645
21	5.5	15.5	0.2	13.8	25.3	32.5	7.2	30.3	793.	.638
22	6.0	16.0	Tr.	14.0	23.5	34.1	6.4	30.4	814.	.650
Av.	5.72	16.38	0.06	12.58	25.10	33.10	6.06	30.47	816.2	.638

ANALYSES OF 10 SAMPLES OF MIXED CRUDE OIL GAS AND CARBURETTED WATER GAS AND AVERAGE ANALYSIS.

June	CO_2	CnH_2n	O_2	CO	H_2	CH_4	N_2	C. P. B.	T. U.	Sp. gr.
11	3.4	9.2	0.4	11.0	37.2	32.9	5.9	21.8	703.	.518
12	3.5	9.7	0.4	9.8	36.6	33.2	6.8	22.9	710.	.522
14	3.4	10.2	0.4	10.0	36.3	33.6	6.1	22.9	724.	.523
15	4.0	10.0	0.4	10.6	35.8	32.5	6.7	21.4	708.	.535
16	3.5	9.3	0.4	10.2	38.3	31.9	6.4	21.6	696.	.512
17	3.4	9.6	0.2	10.0	36.7	34.6	5.5	20.9	724.	.515
18	3.6	10.0	0.4	10.0	37.2	32.3	6.5	21.5	709.	.521
19	4.0	9.6	0.2	10.6	34.5	34.0	7.1	22.1	712.	.540
21	3.8	9.7	0.2	10.0	35.6	33.7	7.0	21.7	712.	.531
22	3.7	9.7	0.4	10.2	37.2	32.9	5.9	22.0	710.	.519
Av.	3.63	9.70	0.34	10.24	36.54	33.16	6.39	21.88	710.7	.5236

THE AMOUNT MADE AND PER CENT. OF OIL GAS AND WATER GAS WHICH CONSTITUTE THE ABOVE ANALYSES.

June	Oil gas made "M"	Water gas made "M"	Per cent. Oil gas	Per cent. water gas
11	6,921	2,095	77	23
12	7,094	2,089	77	23
14	6,664	2,090	77	23
15	6,522	2,090	76	24
16	7,054	1,975	78	22
17	5,976	2,102	74	26
18	6,072	2,102	74	26
19	6,718	2,077	77	23
21	6,742	2,097	76	24
22	5,869	2,060	74	26
Aver.	6,563	2,077	76	24

The early days of oil gas were filled with doubts that it could ever take the place of coal gas or water gas. Doubters prophesied that the gas would not be fixed and that it would be impossible to maintain uniformity in candle-power. These doubts and fears have all been allayed and oil gas as now made in California has the same stability as well made coal gas, with the further advantage that any desired candle-power may be maintained and naphthalene stoppages can be practically controlled from the station.

Oil gas has another advantage which is most important from a humanitarian standpoint. In the days of coal gas, deaths from asphyxiation either accidental or suicidal were infrequent, but after the introduction of water gas the number of deaths from this cause materially increased, this increase was attributed to the greater amount of carbonic oxide contained in water gas. To be sure, illuminating gas is not sold to be inhaled, and when properly consumed the products of combustion of carbonic oxide are no more harmful than those from other gases, but as the percentage of carbonic oxide was greatly increased by mixing water gas with coal gas, and finally

by the use of water gas alone, the mortality from gas asphyxiations correspondingly increased. These facts refer particularly to San Francisco, which has a cosmopolitan population, and more nearly resembles a foreign city than any other place in the United States.

An examination of the coroner's records shows that nearly all of the deaths from gas asphyxiation were suicides, and this leads to the thought that when it became known that illuminating gas containing much carbonic oxide was a simple and convenient means to this end, it became popular. The introduction of oil gas immediately dropped the percentage of carbonic oxide to less than 7 per cent., and deaths from gas asphyxiation became rare. There followed many attempts at suicide which were unsuccessful, persons having deliberately turned on the gas in closed rooms, and after remaining under its influence for several hours, were easily resuscitated. A great many instances of this kind seemed to discourage the use of gas as a means of suicide. The subsequent improvements in oil gas which increased the percentage of carbonic oxide to 9 per cent., and the addition of lampblack water gas, which further increased it to between 10 and 11 per cent., has not increased the mortality from gas asphyxiation, this would seem to prove that very few deaths from this cause are purely accidental.

The question now naturally arises, in what localities can oil gas be made a commercial success? This depends primarily on the cost of oil and as oil gas can be made in large or moderate size machines with 9 gallons of oil, or less, the cost of oil per thousand cubic feet may be easily calculated from the cost of oil per barrel delivered in any given place. Next is the item of labor. In California, and particularly in San Francisco, labor is strongly unionized, and the wages of the men employed in gas works are much higher than in other parts of the country. The hours of labor are invariably 8 hours per day, so that it requires 3 shifts of men to operate any gas making apparatus. Gas makers received $110.00 per

month, their helpers $90.00 per month, and no ordinary laborer is paid less than $2.50 per day for 8 hours work. With these high prices for labor prevailing, it is imperative that the largest units for gas making shall be employed and the large generators herein described have accomplished great saving in the cost of labor in gas making.

During December, 1908, at the Potrero station in San Francisco, the amount of gas made was 267,792,000 cubic feet, and the cost of labor per thousand was as follows:

Generator labor, including gas makers, helpers and all men on the floor	$0.00811
Labor handling lampblack by hand	.00585
(This was before the installation of the crane for handling lampblack, and the estimated cost substituting the crane for hand labor, would be	.00333
All purification labor	.00491
During June, 1909, the total make of gas was 170,776,000. The labor in the generating room was	.00994
Handling lampblack	.00522
Purification wages	.00624

The miscellaneous labor about the works, including firemen, water tenders, engineers, helpers, other mechanics and office help, is about the same as in any economically operated water gas plant where no residuals are handled. The improvements in labor saving apparatus in oil gas making have thus kept pace with the increase in wages and the reduction of hours of labor, so that the present system of gas making is most economical, notwithstanding the obstacles presented by local conditions.

The future of oil gas depends largely upon the price of oil and the practice of economy in the manufacture of gas. The first may be regulated by a gas company owning its own source of supply of oil, and the second rests in the hands of every conscientious worker in our industry.

MR. RUSSELL: I have listened to Mr. Jones' talk with a great deal of interest. It has been my pleasant experience to have had charge in San Francisco of a gas plant during the introduction of the manufacture of oil gas. At first lampblack was all over everything. They were trying to do almost everything with it, except what they are doing now. I wish to corroborate Mr. Jones when I say that, if they had coal tar in California, they would make gas out of it. If they had oil tar in California, they would also make gas out of it. When you come to deal with an oil of from 12 to 15 degrees Baumé, it comes pretty near being of a coal tar constituency, but it is much easier to handle. The problems Mr. Jones has worked out in developing the oil gas industry, and the work done by his fellow workers, and the time in which they did it, I think should command our attention.

The only question in my mind on the oil gas proposition is how long the price of oil is going to justify the present method of making oil gas in California. I will say this, that if the price of oil rises so that this process is not economical any longer, it will be an easy matter to change all of the present oil gas sets into water gas sets, and proceed to make water gas. In other words, we have not wasted a lot of money on a temporary expedient, no matter what the price of oil may be in the future.

THE CHAIRMAN: I will now hand over the meeting to the President, who I understand has some remarks to make.

THE PRESIDENT: Gentlemen, it gives me great pleasure to say that not only have we had a very successful meeting up here, but the meeting below has been extremely successful, so much so that we may dismiss any fears that sectional meetings cannot be made a success.

I am going to ask the members to bear in mind that the body as a whole will reconvene this afternoon here in this hall at 4 o'clock. The sectional meetings will be kept on until that time.

Afternoon Session.

Technical Section.

The meeting was called to order by the Chairman, Vice President Gartley, at 2:30 P. M.

The Chairman: The first paper will be on

Sulphur Compounds in Illuminating Gas,

by Chas. J. Ramsburg.

Mr. Ramsburg being absent, Mr. Fulweiler will read the paper.

Mr. Fulweiler then read the paper, illustrating the same with stereopticon slides.

SULPHUR COMPOUNDS IN ILLUMINATING GAS, WITH PARTICULAR REFERENCE TO THE TESTING FOR HYDROGEN SULPHIDE.

It is my opinion—as well as the opinion of many others—that undue prominence has always been given to the regulation of hydrogen sulphide in commercial illuminating gas. It is my purpose, therefore, to bring to your notice the history of the subject and to point out some features of the matter which I feel assured will prove of interest. In the matter of sulphur regulation, the subject has been almost entirely developed in England. The fact that water gas is the predominating product in this country has been the cause of an almost complete indifference.

But, whether coal or water gas is the product, the subject of hydrogen sulphide is of equal interest.

The tests for hydrogen sulphide are delicate, though simple, and the real purpose of this paper is to bring to your attention the fact that many of the commonly used tests for this compound are so very delicate as to be an absurd and unnecessarily expensive requirement for the gas company. This part of my subject I will take up later.

A brief synopsis of the history of the agitation in England, as accurately as I can discover, is as follows:

The first act regulating the purity of London gas became operative in 1860. This test specified that "the presence of sul-

phuretted hydrogen is prohibited under a penalty of £50," and also prescribed that not over 20 grains of sulphur, other than H_2S, should be allowed. Sir George Livesey, in his testimony before the Committee on Metropolitan Gas Testing, in 1904, says:—

"The Metropolitan Gas Act of 1860 prescribed that....the gas should be so far free from....sulphuretted hydrogen that it shall not discolor....paper imbued with acetate of lead, or carbonate of lead, when the paper is exposed to a current of gas issuing for one minute under a pressure of five-tenths inches of water, and shall not contain more than 20 grains of S in any form in 100 cubic feet of gas.

The test for hydrogen sulphide worked satisfactorily to all parties—but the sulphur limit of 20 grains was a dead letter, it being found impossible to comply without the use of lime, and the remembrance of the great nuisance it caused was an effectual bar to its resumption. The sulphur fad originated with Dr. Letheby, when Medical Officer of the City of London, and acting as the Gas Examiner of the General Central Company's gas in the fifties. At, or about, 1850, lime had been displaced by the clean and innocuous oxide of iron and the abolition of the nuisance of lime was a very great relief to the neighborhood of the gas works."

We can see from this that the first law on the subject was one which originated with a medical officer in a great city, one zealous in his duties, rushing into an assumption without proper data, formulating and having passed a law which could not be complied with, except at a great expense, and which would only result in the creation of a much greater nuisance. It is commendable that it was not enforced.

In the Gas Act of 1867, passed in 1868, there appears a new factor in the situation; mainly, the provision for the appointment of the London Gas Referees. The Board of Trade were required "to appoint three competent and impartial persons, one at least to have practical knowledge and experience in the manufacture and supply of gas, who shall be called the Gas Referees." They were authorized to inspect the "works of

the companies and investigate the processes of manufacturing carried on therein, with the view of ascertaining the means adopted therein for purifying gas and preventing nuisance, and may from time to time apply all such tests as they think expedient, at the works of the companies or elsewhere, for ascertaining the amount of sulphur and ammonia and compounds thereof or other impurity in each form, which gas supplied by the company shall allow to be charged."

Amongst the other duties assigned to them was power to prescribe and certify from time to time the manner of testing and recording the purity of the gas. Section 39 of this Act also provided, that the gas supplied should be wholly free from hydrogen sulphide and that nothing in that Act should authorize the Gas Referees "to allow of gas being charged with any amount of impurity in that form." Thus, we see the control of the situation passed into the hands of the Gas Referees—appointed by the Board of Trade.

In regard to the appointment of the Gas Referees, Mr. C. E. Jones, Assoc. M. Inst. C. E., of Leyton, in an article in the London Journal of Gas Lighting, in November, 1903, written in anticipation of the examination about to be made of the gas condition by a Committee of the London Board of Trade, says:—

"After the elimination of sulphuretted hydrogen, there remains 40 or 50 grains of sulphur in other forms than sulphuretted hydrogen in every 100 cubic feet of the purified gas—probably 30 to 40 grains of this is sulphur combined with carbon as CS_2—an important and interesting compound which has been the means of creating the honorable Board of Gas Referees. But for the objectionable presence of this substance, and a desire to remove it altogether, and with the unknown sulphur compounds which continue to defy isolatory efforts—it is morally certain that other means than refereeism would have been adopted."

On the basis of this authority, it would seem that the principal reason for the appointment of the Gas Referees was to draw up tests for the control of sulphur compounds and to

make such regulation as would keep it within bounds—commercially and hygienically. The development of the control of the sulphur content under the Gas Referees has been as follows:

The first "instructions" were issued in 1868, providing tests for hydrogen sulphide and other sulphur compounds.

The test for hydrogen sulphide provided a bibulous paper, saturated with lead acetate to be hung in a glass vessel, through which gas must pass for the illuminating test and was to continue until the completion of that test.

The sulphur compounds test was that originated by Dr. Letheby and was as shown in Appendix A.

No change of consequence was made until 1872, when the present well-known test for sulphur compounds other than H_2S was devised, consisting as shown in Appendix B. In this year, after many experiments, the Gas Referees submitted an elaborate report on the occurrence of sulphur in gas, effect of washing and scrubbing, amounts found by the gas examiners, and showed conclusively the superiority of the "Gas Referees Test" over the Letheby Test. There was no further change for some time. In January, 1872, the Gas Referees submitted a report on sulphur purification to the Board of Trade. This report goes into the greatest detail into the purification problem and shows the causes for the failure of a very expensive plant for purification at the Beckton Works, London, and compares the gas sent out there with the gas from other plants without such apparatus. I gather from this, that they are largely to blame for the failure of the system and issued the report to clear up the causes. In the summer of 1873, all the works were required to keep sulphur compounds below 20 grains.

In the winter of 1873-74, raised to 30 grains.

1874—reduced to 25 grains.

April, 1875—cut maximum sulphur content to 15 grains at Bromley Works; all others to 20 grains.

1875, October—20 grains for some works, 25 for others. So instructions were issued—summer and winter until 1881.

In 1887, an important change was made in the H_2S test. This provided that the gas instead of being passed over the lead acetate paper for the time of testing the illuminating power (5 ft. rate) should be impinged on a paper at the rate of ½ ft. per hour for twenty hours. See Appendix C. This made a very severe test and was in vogue until 1899, when the test was modified slightly, in that the paper must show a *distinct* coloration.

In January, 1904, the allowable limit of sulphur compound was set at 17 and 22 grains in summer and winter respectively, "unless the average quality at any testing place for the 13 days immediately preceding said testing shall have been less than 12 grains, in which case, the maximum at any time of the year at that testing place shall be 27 grains."

So the matter of sulphur content control rested until the year 1904. In January of that year, feeling the pulse of general opinion that new conditions demanded new methods, there was appointed by the London Board of Trade, a "Departmental Committee of the Board of Trade on questions relating to the quality and testing of London Gas." This Board was made up of Lord Rayleigh, Chairman (noted among other things as the discoverer of argon), Sir William deW. Abney, Mr. Robert Farquharson, Mr. William King and Mr. J. Fletcher Moulton. This Board sat over 21 days, and thoroughly investigated the subject. From the standpoint of sulphur, the following was recommended:—

Section 15.—"The existing tests for sulphuretted hydrogen is a very severe one; and, in the opinion of the Gas Referees and many other witnesses, the requirements of the Special Acts, that the gas shall be wholly free from sulphuretted hydrogen, may safely be made less stringent. The Committee concurs in this view and consider that a three-minute test with moistened lead paper such as that described by the Gas Works Clauses Act of 1871, would sufficiently guarantee the practical freedom of the gas from this form of impurity. The mode of testing should be left to be prescribed by the Gas Referees

as at present. (The Gas Works' Clauses Act of 1871 repealed the law of 1847 and was in reference to locations outside of London).

Section 16.—"With regard to the injurious effects of the presence in gas of sulphur compounds other than sulphuretted hydrogen, the evidence is conflicting. But, it is not disputed that only a small percentage of the gas undertaking in the United Kingdom are required to take these sulphur products out of the gas they supply. Nevertheless, it does not appear that any complaints are made by the inhabitants of other districts on the ground that the gas thus unpurified causes injury to health or is more destructive to articles such as leather, etc., than it is supposed to be in London. In the face of this striking fact, the Committee are of the opinion that those who contend for the maintenance of the clauses relating to sulphur compounds other than sulphuretted hydrogen have not sufficiently shown that their abolition in the case of the London companies would be detrimental to the public."

Section 17.—"After careful consideration of the evidence submitted them on this question, the Committee are of the opinion that the requirements that the sulphur impurity should be removed to such an extent as to demand the use of lime shall be discontinued, and in view of the fact, that no effective substitute for lime has been found, they abstain from suggesting the imposition of any modified restriction in the place of that existing. The Committee accordingly recommend—

(e) That the existing statutory provision which requires the gas to be wholly free from sulphuretted hydrogen (which is in fact impracticable) should be modified and that for the future the tests which the gas should be required to pass should not be more severe than that specified in the schedule in the Gas Works' Clauses of 1871.

(f) That obligation placed upon the company with regard to the removal of sulphur impurity (other than sulphuretted hydrogen) should be abolished, but that testing for information only should be continued to be made in such manner and to such extent as may be prescribed by the Gas Referees.

(Note) The Gas Works' Clauses Act of 1871, prescribed a three-minute test at a five-foot rate—gas not impinged."

The effects of the report of this Committee was to influence the passing of a new Gas Act in 1906. This enacted on the subject as follows:—

Section 6.—"The gas supplied by the Company shall not exhibit any trace of sulphuretted hydrogen when tested in a mode to be from time to time prescribed and certified by the Gas Referees for testing and recording the presence of hydrogen sulphide, which mode shall not be more stringent than the mode prescribed in Section A of the Gas Works' Clauses Act of 1871—and Section 15 of the Act of 1880 should apply accordingly."

Section 7.—"After the commencement of this Act, the Company shall not be liable to any forfeiture by reason of the presence in the gas supplied by the Company of sulphur impurities other then H_2S and the Gas Referees shall not prescribe nor certify the amount of sulphur impurities other than H_2S with which the gas supplied by the Company shall allow to be charged."

Thus, was the matter cleared up to the satisfaction of the Companies. The law allowed only a three-minute test for H_2S and the sulphur compounds were removed from restriction.

Following this law, the Referees issued the following instructions in January, 1906:—

"Sulphuretted Hydrogen: The apparatus used in testing gas for the presence of H_2S is figured in Appendix H (See Appendix C to this paper). The gas as it leaves the service pipe shall be passed through the glass vessel in which are suspended strips of bibulous paper which have been recently moistened by dipping them in a solution consisting of 100 grains of crystallized acetate of lead dissolved in 100 c.c. of water. One testing shall be made daily. In making the test, gas shall be turned on the apparatus and lit at the burner as soon as the air has been swept out. When the gas has burned for three minutes, it is to be turned off, and one of the slips of paper is to be

compared to another similar slip which has not been exposed to the gas. The gas is to be taken as showing the presence of hydrogen sulphide if the slip of paper which has been exposed is unmistakably the darker of the two.

So much for a brief history of sulphur agitation in England. So brief as to bring out little to indicate the immense amount of controversy and discussion. As it stands to-day, however, the matter so far as English gas undertakings are concerned, is in excellent shape. No sulphur, which can be removed, commercially and without nuisance, is allowed. In other words, the H_2S must be removed. A test, however, is provided which allows a strong trace to pass unnoted.

The compounds other than hydrogen sulphide are permitted to remain in the gas. Why this was done and what its effect has been will not be discussed here.

In our own country, the decisions of the London Gas Referees and their instructions as to tests to be made have been closely followed, where laws have been made and by the gas companies themselves independently where there were no laws. At the present time, in this country, there are but four states and the District of Columbia where the amount of sulphur compound content is the subject of laws; namely, Wisconsin, Massachusetts, Connecticut, and New York. Following closely the old English laws, and probably somewhat blindly, the total sulphur permitted is 20 grains in the latter two; in Wisconsin and Massachusetts 30 grains are permitted. The law in regard to H_2S is stringent, permitting but a trace. The law in these localities is as follows:—

STATE LAW IN REGARD TO SULPHUR IMPURITIES EXISTING AT PRESENT.

DISTRICT OF COLUMBIA:

That Section 1 of an Act entitled "An Act regulating Gas Works," approved June 2nd, 1874, is amended so as to read as follows: "That from and after the 30th of June, 1896.... gas furnished by any gas light company, person or persons, shall contain not more than 20 grains of sulphur in any form in

100 cubic feet, and shall be free of the impurity known as 'sulphuretted hydrogen;' said impurity to be determined by passing the gas through a glass vessel containing strips of bibulous paper moistened with a solution of acetate of lead, and if any discoloration of the test sheet is found to have taken place, this is to be held conclusive as to the presence of sulphuretted hydrogen in the gas." Penalty $100.....

STATE OF NEW YORK: Commission of Gas and Electricity.

"That each 100 feet of said gas shall not contain more than 20 grains of sulphur compounds....and it is further ordered that the gas sold or manufactured shall exhibit no trace of hydrogen sulphide when tested as follows:

"If a strip of white paper, moistened with a solution of acetate of lead, exposed to a current of gas flaming at the rate of 5 cubic feet per hour, does not after 30 seconds of such exposure become colored, the gas shall be considered to contain no hydrogen sulphide.

WISCONSIN:

"In no case shall the gas contain more than 30 grains of total sulphur per 100 cu. ft., and not more than a trace of sulphur as sulphuretted hydrogen."

MASSACHUSETTS:

The law provides that when the gas of any company is found to contain on three consecutive inspections more than 30 grains of sulphur or any H_2S, a fine of $100 shall be paid.

CONNECTICUT LAWS:

May 14, 1903—Bill No. 143, regulating the supply of gas in that state. The following is the text, section 1, "Sections 4, 5, 6 and 9, of the general statutes is hereby amended to read as follows:

"The standard measure for sale....a light of 16 standard sperm candles, 120 grains per hour—not more than 20 grains of sulphur or more than 10 grains of ammonia per 100 cu. ft. or any sulphuretted hydrogen. Penalty $100....."

Section 4573: Test:—

"The test for sulphuretted hydrogen shall be made by allow-

ing a stream of gas flow through a round orifice not larger than 1/32 of an inch in diameter, under a pressure not greater than 1.5 inches of water and to impinge on a paper moistened with a solution of acetate of lead, placed at a distance of one inch from said orifice for a period of three minutes and if the paper shall be distinctly discolored within that time, it shall be deemed that sulphuretted hydrogen is present within the meaning of this act."

Various municipalities have their own Sulphur Clauses:

OMAHA—EXTRACT FROM ORDINANCE 4682:

Section 3.—"Gas supplied by any person, firm or corporation, to consumers within the City of Omaha, shall not contain more than 15 grains of sulphur in any form in 100 cu. ft. of gas and shall be free from the impurity known as hydrogen sulphide to be determined by passing the gas through a glass vessel, containing trips of bibulous paper moistened with a solution of acetate of lead, and if any discoloration of the test paper is found to have taken place, this is to be held conclusive as to the presence of H_2S in the gas; and such gas shall be free from all other impurities, producing noxious products of combustion."

PHILADELPHIA:

"The gas shall be of good quality."—This leaves it to the Municipal Inspector to determine what is gas of good quality. He interprets it, by the adoption of the H_2S test used by the London Gas Referees previous to 1906. A 20 hour impingement test.

BOSTON:

"A piece of soft white paper is dipped in a solution of lead acetate and held while moist in a small stream of gas ½" from the orifice for 60 seconds. Absence of color indicates no H_2S."

Chicago:

Hydrogen Sulphide: No more than a trace should at any time be found in the gas.

Total Sulphur: 20 grains.

Method for testing not prescribed.

Milwaukee Method:

The Hydrogen Sulphide test in use by the City Inspector at Milwaukee consists of a 5″ piece of 1″ glass tubing set upon a pillar cock, closed by perforated rubber stoppers at both ends, the lower stopper being fitted into the pillar cock, connected with the gas supply and the upper stopper being fitted with a 5 ft. Bray burner. The test paper, prepared in the usual manner, of bibulous paper, is placed in this tube and the upper stopper replaced, the gas turned on and burned at the rate of 5 ft. per hour during the period in which the photometer and the calorimeter tests are being made, perhaps averaging about 1½ hours for each test.

There is also a total sulphur test made once each week by use in the usual manner of the London Gas Referees' apparatus.

The subject of sulphur compounds other than Hydrogen Sulphide has lately been the subject of some interest in this country, and I wish to draw your attention to an article written by Dr. A. D. Little, of Boston, on this subject. The matter of increasing the allowable sulphur in the State of Massachusetts had been under discussion and his paper was submitted as a report. Mr. Little's conclusions were substantially the same as reached in the London Board of Trade Committee; namely, that there was every reason to believe that any amount of Sulphur existing as compounds of S other than H_2S, from a gas coal of good quality or even fair quality, would not be injurious to life or property. The Massachusetts Board, however, only raised the maximum from 20 to 30 grains in their instructions.

In regard to Hydrogen Sulphide, all laws here and abroad prescribe that there shall be but a trace present. In some

instances, the method of testing is prescribed—in others, it is left to the discretion of the inspectors. Because so little about this testing for H_2S is generally known, I will try to bring out, what these tests are, how they are made and show how much H_2S will be defined as more than a trace in the commonly accepted tests.

First, let me call your attention to data derived from English researches; W. J. Dibdin and R. G. Grimwood in a paper read before the English Society of Public Analysts in 1902, have the following to say:—

"Owing to a recent proposal to modify the test for sulphuretted hydrogen as used on London Gas Supply, it became necessary to ascertain—as no public data could be found on the point—what was the best means of estimating small quantities of H_2S in Coal Gas and what degree of delicacy could be attained in its detection."

After some descriptions of various attempts to find a method, he continues:—

"Recourse was therefore had to the coloration of lead salt which is the system now in use. Although it is well recognized that this reaction is a very delicate one, it is somewhat surprising to find how extraordinary its delicacy is. In fact, instead of there being any difficulty in detecting minute traces, the difficulty is to modify the test so as not to detect them. The coloration of papers soaked in lead salt was next examined—papers soaked in various strengths of lead salt being compared. From the result of this comparison, it was decided to adopt a paper prepared by moistening with an approximately 12 per cent. solution of lead acetate; the paper while still wet being placed in an atmosphere of ammonia gas. Papers prepared in this way are used in London for testing the purity of the gas supply. For several reasons, it was found preferable to use these papers dry, considerable difficulty being experienced in distinguishing when the color first appeared on a wet paper and also when wet, they were unworkably sensitive."

The result of their research is shown in the following tables, the second being a translation to the grain-per-foot-system:—

TABLE I.

	Distance of lead paper from nozzle							
	Close to A		⅛″ B		¼″ C		½″ D	
	Min.	Sec.	Min.	Sec.	Min.	Sec.	Min.	Sec.
Time taken to produce a color on lead paper by gas containing one volume of sulphuretted hydrogen	[1]		[1]		[1]		[1]	
1,000 vol.	0	2	0	4	0	8	0	12
10,000 "	.	5	.	10	.	15	.	18
250,000 "	.	8	.	15	.	30	.	.
1,000,000 "	1	7	1	30	1	50	2	20
10,000,000 "	5	0	.	.	12	0	.	.
100,000,000 "	11	30	.	.	21	30	.	.
1,000,000,000 "	.	.	.	.	.	.	.	.
10,000,000,000 "	[2]		[2]		[2]		[2]	

TABLE II.

	Distance of lead paper from nozzle							
	Close to		⅛″		¼″		½″	
	Min.	Sec.	Min.	Sec.	Min.	Sec.	Min.	Sec.
63.0 grains per 100 cu. ft.	[1]		[1]		[1]		[1]	
6.3 grains per 100 cu. ft.	0	2	0	4	0	8	0	12
.252 grains per 100 cu. ft.	.	5	.	10	.	15	.	18
.063 grains per 100 cu. ft.	.	8	.	15	.	30	.	.
.0063 grains per 100 cu. ft.	1	7	1	30	1	50	2	20
.00063 grains per 100 cu. ft.	11	30	.	.	21	30	.	.

[1] Spot produced at once.

[2] Spot produced after more than 30 minutes.

In the discussion on this paper, it was brought out that Dr. Rident had determined that the delicacy of the official test for sulphuretted hydrogen (passing ½ ft. per hour) for 20 hours and impinging it on the paper) "would detect one part in 5,000,000, or a content of .012 grains per 100 cubic feet, or.....roughly 1/80th of a grain."

It is not necessary to mention at all or go into the chemical theory of the commonly used lead paper test, suffice it to say that the delicacy of the test is almost beyond belief. Not only is it delicate, but the delicacy is coincident with extreme simplicity. To the lay mind—the test made by means of a lead acetate paper (moist) held in a stream of gas, containing one part in 1,000,000 would indicate the presence of a very considerable amount. I have no doubt that this simple delicate test has cost the gas companies of the world an immense sum, and the benefit has been almost negligible.

Being impressed by this fact, while engaged in the study of the manufacture of oxide which would be sensitive to the removal of small amounts, I thought it a matter of such interest as to venture to draw it to the attention of the Institute.

The following is an account of experimental work done in this connection. An attempt was made to isolate 50 feet of gas, containing a small amount of H_2S, ½ grain per 100 cu. ft. and to use this to follow out the prescription for the various tests. Great difficulty was experienced in doing this because an attempt was made to place a known volume of H_2S in a definite volume of gas and to calculate what the content was. This method was abandoned after many fruitless attempts—the H_2S always disappearing almost immediately, and recourse was had to another method. The water in a 50 ft. photometer experimental holder was saturated with foul coal gas from which the tar and ammonia had been removed. When clean gas was put into this holder and allowed to stand, it was discovered that at a temperature of 74 degrees (ordinary room temperature) this gas contained 53/100ths grain per 100 cu. ft. without further addition.

This amount was determined by use of the cadmium sulphide test as given by Hornby in his Gas Engineer's Laboratory Handbook. See Appendix E. A check on two successive days gave 51/100ths and 53/100ths grain per 100 cu. ft. I may say that this test is a very delicate, and rather arduous one, but gave great satisfaction. Having secured the 50 feet of gas containing approximately ½ grain in 100 cu. ft. the tests were made according to the methods of various localities.

PLATE I—LETTER A:

Shows the test used in New York State. The method has been referred to earlier in the paper, but you will recall that the test calls for a clean paper when held in a 5 ft. stream for 30 seconds. You will note that this small amount of H_2S produced a distinct color in ⅙th of this time, indicating that less than 1/10th of a grain was incapable of passing the test.

Letter B—Shows the Connecticut test.

Letter C—the method in use in Boston.

These three are all in practical use at this time. It is not necessary for me to speak of these separately. The result of the test is evidence of its severity.

Now let us turn to Plate II.

Letter B—shows the continuous test, known as the "Referees Test." This is the same test to which I referred as being sensitive to 1/80th of grain—according to Dr. Rident. Let me state that the test paper shown began to turn in less than 10 minutes.

Letter A—on this plate shows the result of the present "Referees Test." In this, you will note no change on the one-minute—slight on the two—while the three-minute shows a rather distinct color.

Letter C—shows the method in use at Milwaukee to detect the "trace" allowed by law. From the looks of letters B and C, I am sure that the average uninformed person would think the gas to be entirely hydrogen sulphide.

It is not my purpose to dwell heavily on this matter, but one thing must be clear: that these tests border on the ridiculous. What does ½ grain in 100 cubic feet mean? It means 1/14,000 of a pound in a hundred feet. Forty—even one hundred times this amount of carbon di-sulphide is allowed—properly without notice—but all of this H_2S must be removed because of the chemical phenomenon that anyone can find it and see it who has a piece of lead paper. Any school-boy in a laboratory is likely to tell what poor gas the gas company supplies—"just look at this paper I held in the gas jet for one minute." What does it mean to the gas company and to the public? To the gas company which operates in New York, Wisconsin, Connecticut, Massachusetts, or in the District of Columbia, it means first, in spite of continued vigilance of a high order, liability to penalty—it means the unnecessary expenditure of money in shifting boxes and increased capitalization in unnecessary purifying capacity. To the public it means nothing at all, unless it be said that the line must be drawn somewhere. But the point is, that as the H_2S becomes diluted, it is increasingly difficult to remove. An allowance of a grain of hydrogen sulphide would be a factor of benefit to the public. It is a well-known phenomena that old oxide containing a large amount of free sulphur will remove a considerable amount of carbon di-sulphide, and I venture to state that by allowing up to one grain of hydrogen sulphide present, that the total sulphur would be decreased—for the immediate effect of doing this would be to have every gas company shift its boxes when the outlet showed traces instead of the second box and the inlet box would consequently run much longer and containing more free sulphur would remove more of the other S compounds. Let us again refer to the tables.

By a study of the table transposed into grains-per-100 cu. ft., you will note that if the gas were tested on the outlet of a purifying box, in the manner usually in vogue, of holding a piece of lead acetate impregnated paper within ⅛" of a pet

PLATE I

Hydrogen Sulphide Test — Gas containing .53 ($\frac{53}{100}$) grain per 100 Cu. Ft.

New York Method.

Paper moistened with Lead Acetate solution held in a stream of gas - flowing at 5 Cu Ft. per hour - for 30 Seconds.

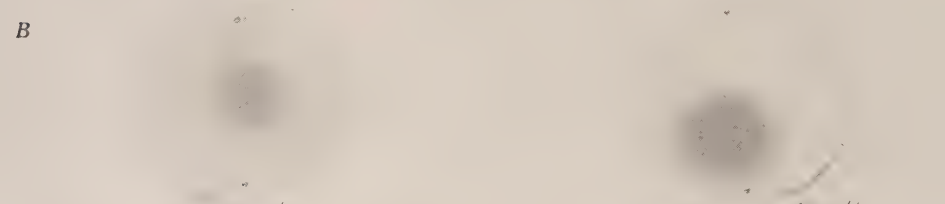
A

5 Seconds. 10 Seconds 20 Seconds 30 Seconds (Te

Test Prescribed by Law in State of Connecticut — Gas containing .53 grain per 100 Cu. Ft.

Gas passed through orifice $\frac{1}{32}$" in diameter - pressure 1.5" for 3 minutes. Moist paper.

B



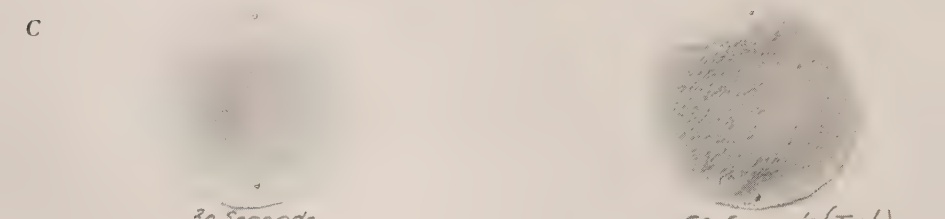
1 Minute 3 Minutes (Test)

Boston Method (Used by Inspector) Same Gas.

Method not prescribed by Law.

Moist Paper (Lead Acetate) held in stream of gas for one (1) minute - $\frac{1}{2}$" from orifice.

C



30 Seconds. 60 Seconds. (Test)

Present Referee's Method

Gas containing .53 ($\frac{53}{100}$) grain per 100 Cu.ft.

Moist paper placed in small glass bell jar for 3 minutes - flow of gas at 5 ft. rate.

A

1 Minute | 2 Minutes | 3 Minutes (Test)

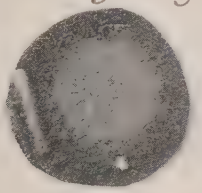
London Gas Referee's Method - Previous to 1906

At present in common use in this Country

Pass 10 ft gas - impinged on paper - at rate of $\frac{1}{2}$ ft per hour

Gas containing .53 grain per 100 Cu.ft.

B



Dry (Test)

Milwaukee Method

Wet

Gas containing .53 ($\frac{53}{100}$) grain per 100 Cu.ft.

Paper (dry) placed in 1" Glass tube - 5 inches long

Gas passed for time of test ($1\frac{1}{2}$ to 2 hrs) through tube.

C

1 hour.

2 hours. (Test)

cock, gas, containing ¼ grain of H_2S will turn the paper in ten seconds. Perhaps, this is generally appreciated, but I do not believe it. Having tested and found a "show" it is customary to make a shift. I believe that the method prescribed for official testing should allow up to at least one grain of H_2S present without unfavorable report. It is customary in most plants to run four boxes (three of which are in use) and to make a shift when there is a show on the outlet of the second box. Mr. E. H. Earnshaw, in a paper presented before the American Gas Light Association, says as follows:—

"When we first began the study purification with the assistance of the iodine burette (The Tutwiler Burette) we were very much impressed by the very great amount of work done by the first box of the series. The first box does mainly all the work, even up to the time that it is taken off as 'foul'. For some reason, as the number of grains of H_2S become smaller, it is increasingly difficult to purify the gas. It sometimes takes a greater volume to remove the last 10% of the sulphuretted hydrogen than to take out the first 90%."

It can readily be seen that in a system embracing four boxes (one idle) with a shift being made when there is a show on the outlet of the second box (and a shift must be made in order to insure absolutely clean gas on the outlet) that there is a large increase in the cost of purification and a corresponding increase in the capital invested. Does this not appeal as a needless and wasteful expense? With a proper test, allowing a margin of a grain it would be possible to run the boxes until there was a slight show on the outlet of the third box—allowing the continuance of the material in operation in the first box until it is much more 'fouled' than under present practice. This would cut the labor of purification down greatly and increase the purification capacity correspondingly.

It will be of interest to review in this connection some of the testimony before the Metropolitan Board on Gas Testing before mentioned in 1904.

Mr. A. G. Vernon Harcourt, F. R. S., gave testimony as follows; reading a statement on behalf of the Gas Referees, he said:

"Statutory requirements relating to the purity of the gas supplied by the Metropolitan Gas Companies.

"The Committee will observe that the Gas Referees stand in a different relation to questions of illuminating power from that in which they stand in relation of questions of purity." .... The Gas Referees have nothing to do with the prescription of the illuminating power of the gas, nor the choice of a burner, whereas in regard to the purity of the gas not only modes of testing, but also the decision as to the amount of impurity with which the gas supplied by the company shall allow to be charged, are committed to the Gas Referees. To this, there is one exception. In the acts of all the companies, it is provided that 'gas supplied by the company shall be wholly free from sulphuretted hydrogen.'"

"The mode of testing described by the Gas Referees would show the presence of a very small proportion of sulphuretted hydrogen and has been accepted as sufficient by the chemists of the London County Council and by gas consumers, though it would not be difficult to prove sometimes gas which passes this test is not wholly free from sulphuretted hydrogen. The fact is that the Gas Referees have understood the instructions of the Act of Parliament cum grano; we know that you cannot absolutely remove the whole of an impurity from gas and, although the terms of the Act are so stringent as not to authorize us to allow the presence of any amount we thought that a test might be prescribed by us which was abundantly severe—far too severe, as this committee will hear, in the opinion of those who are interested in the supply of gas—but yet by no means so severe a test as would be possible to devise."

Continuing the testimony, the Chairman asked,

"But after the gas is burned, it makes no difference whether the sulphur was in the form of H_2S or CS_2?"

Answer: "Not at all."

"Do you think the tests as to H_2S is a burden to them (the companies) now?"

Answer: "Only in that way. (Too strict)."

"Do you think there is any desire on their part to substantially change the purity so far as H_2S is concerned?"

Answer: "I think not."

"I am not speaking as to changing the test purity, but you do not think that they want substantially to make it less pure as regards sulphuretted hydrogen? Well I will say "materially" if I may substitute that word for "substantially." I do not think that it would be done to the prejudice of the consumer. I think there would be more sulphuretted hydrogen in the gas if the change was made than there now is, by a little amount, but the whole quantity dealt with is exceedingly small and, as the Chairman has said, in the ordinary use of gas it is completely burned. In any case, it would be a very small addition to the amount of sulphur in the gas. Suppose they were allowed to have one grain of sulphur in the form of sulphuretted hydrogen in 100 cubic feet of gas, and if it were the case (as I believe it is) that they would not keep the whole amount of sulphur present in other forms at less than 11 or 12 grains of sulphur, then when the gas came to be burnt, the addition of this one grain is a small matter and would give them complete relief."

"In your view, the question rather concerns the testing of the gas than its behaviour; you think it would behave just the same, but the test would have to be changed?"

Answer: "Yes."

"Would it be easy to devise a test which would permit some sulphuretted hydrogen, but not much?"

Answer: "I think so. I think it could be dealt with quantitatively. I think it would not be difficult to have a test which would definitely indicate the presence of so small a quantity as one grain in 100 feet and in that case there would be a return that the amount of sulphuretted hydrogen was not

larger than the amount which was allowed, just as is now done in the case of ammonia. In the case of ammonia there is a return of the actual amount—it may be one, or two, or three grains in a 100 feet—the maximum amount being four grains. I think that it would be found that the amount of sulphuretted hydrogen would uniformly fall below a very small amount, which is named in the same way as it is named for ammonia."

"And as a chemist, you could design a test of that kind?"

Answer: "Yes, I feel sure."

Chairman: "Your view is that the severity of the requirements in respect of sulphuretted hydrogen depends rather upon the fact that there is a very delicate test for sulphuretted hydrogen, and on the fact that it is comparatively easily removed from the gas rather than upon the special importance of removing it. Is that so?"

Answer: "Yes. But, as I have mentioned in the paper I have just read, I think it is more important to remove the sulphuretted hydrogen than to remove the carbon bi-sulphide. I believe that a small amount of it would be injurious. I think that it would be found that the gas taps stuck very much if there were any considerable quantity either of ammonia or sulphuretted hydrogen in the gas which is supplied. Also, fortunately, they can easily be kept down to a lower point than the other impurities."

Mr. Moulton: "Would that one grain of which you speak at all affect the smell? I do not think coal gas can smell too bad."

Chairman: "The smell of unburnt gas, you mean?"

Answer: "Yes."

Mr. Moulton: "You look upon the bad smell as a good danger signal? Yes, it is very important, too. I do not think it would make it smell."

"You were speaking of the possibility of one grain per 100 cu. ft. of gas. Then, you spoke of a "considerable" quantity and that the quantity might become more than "con-

siderable" on the possibility of restrictions being withdrawn. One grain would be large compared with the present limitations, but I do not think it would be an amount in any way injurious."

Chairman: "Then, we may take it that you favor a relaxation of the present stringency as regards sulphuretted hydrogen, but that you would maintain the standard as regards the other forms of sulphur?"

Answer: "Yes."

Mr. Boys, another Referee then testified substantially as Mr. Harcourt had done, bringing out, that the fact that the H_2S test was unnecessarily severe.

Dr. J. S. Haldcu, another Referee, testified as follows:

"I should like to ask a question with regard to the sulphuretted hydrogen test. I think in the Gas Works' Clauses Act of 1871, the test was, to expose the paper, moistened with a salt of lead, to the action of the gas, for three minutes. What do you say of that test?"

Answer: "The objection to that test is that it only lasts over the three minutes."

"But, what would you say of gas which under that test showed no signs whatever on the lead paper?"

Answer: "I should say that it was for all practicable purposes absolutely satisfactory so far as the sulphuretted hydrogen was concerned. Of course, the moistened lead paper is a severer test in itself than dry lead paper, which is prescribed by the Gas Referees of London."

"But, I wish to have your opinion of that prescribed by the Act."

Answer: "I think that any gas that would not show a stain, or a very distinct stain, I should say in three minutes, would be quite satisfactory, as regards sulphuretted hydrogen. That is my personal opinion."

Professor Lewes: In his testimony says as follows:

Chairman: "You spoke just now in the manner in which

the test for sulphuretted hydrogen was carried out but you are aware that the Act of Parliament forbids the presence of any sulphuretted hydrogen in gas at the present time."

Answer: "It does undoubtedly. Then the question is, is the expression 'any sulphuretted hydrogen' a commercial expression, or is it a scientific expression? Are you preparing the gas (as I put it just now) as a sample for a museum or are you preparing gas for consumption by the public?"

"But in any case you would favor a relaxation of the test?"

Answer: "Yes—undoubtedly."

It is not necessary to go further with this testimony. As I have shown, the committee finally advocated the adoption of a less stringent H_2S test, which was adopted by the Gas Referees.

I think that Professor V. B. Lewes' question, as to whether the gas was to be submitted to a museum or tested as to its commercial purity, is the proper viewpoint.

Gas tested and found satisfactory by any of the aforementioned State and Municipal tests is certainly worthy of being a museum specimen. It is certainly far beyond any commercial purity.

An interesting experiment to use as an apt and conclusive illustration of the extreme delicacy of the H_2S test is to blow cigar smoke on a test paper. It will immediately darken from any quality of cigar or cigarette. The absence of any trace on a plain piece of the same kind of paper, when so tested, proves the change to be due to H_2S.

I have made no argument in regard to the sulphur compound content. This has already been so completely covered by Mr. Little in his recent report, as to make it unnecessary (see *Progressive Age* of April 14, 1909).

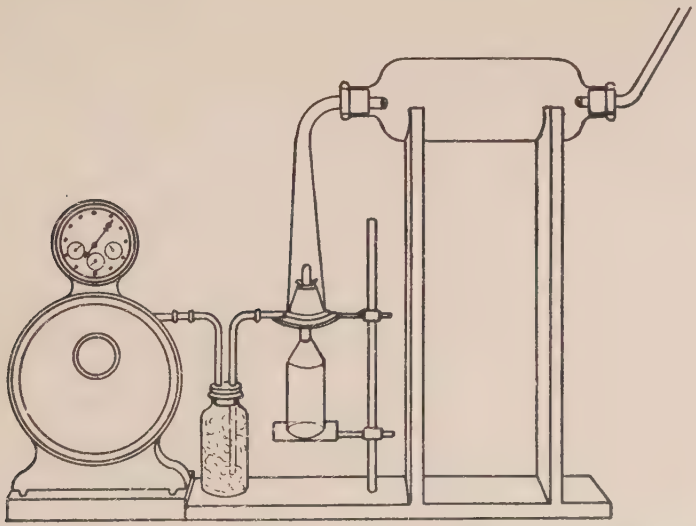
In regard to the question of finding a test which would be better than the lead paper test, it would be a difficult matter to find anything which could be operated with anything

like the simplicity. I believe, however, that should a law be passed in any community, allowing one grain of hydrogen sulphide as a maximum, that a 24 hour test on the principle of the cadmium sulphide test herein referred to (see appendix) could be devised which would answer every purpose.

I believe that the effect of this would be to save considerable money at the present time practically wasted, to employ present capital to better advantage and, finally, to deliver to the consumer a gas which would contain no more total sulphur content than at present.

APPENDIX A.

Letheby Test for Sulphur Compounds in use up to 1872 in England.



The gas after passing through a meter to measure the quantity, is introduced into a bottle filled with small pebbles, wetted with sulphuric acid diluted in the proportion of 20 fluid ounces of strong commercial sulphuric acid to 30 fluid ounces of water, the object of which is to absorb all the ammonia. The inlet-tube to the bottle passes one inch only

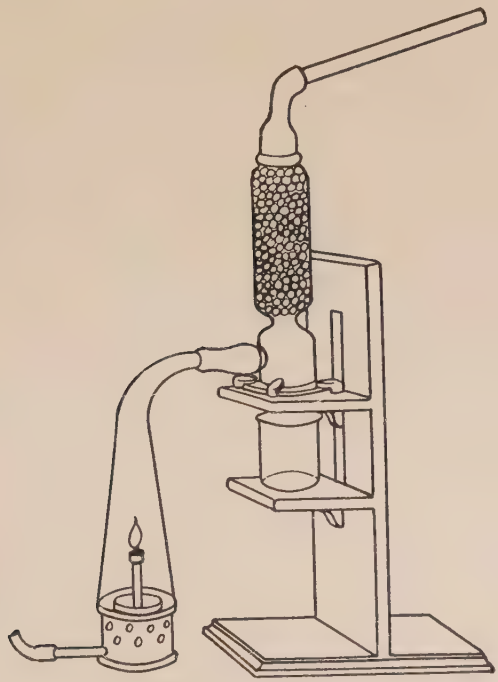
through the cork, while the outlet-tube reaches nearly to the bottom of the bottle, by which arrangement the gas is forced to pass downwards through the wetted pebbles.

The gas thus freed from ammonia is burned with a Leslie burner, placed under a long funnel-shaped tube, at the rate of about half a foot per hour. The upper part of this tube is connected to the end of a large glass receiver, the other end of which is fitted with a glass tube, about four feet long, so arranged that any products of combustion condensed in it will flow back into the large horizontal receiver. The flame is supplied with the vapor of ammonia from a wide-mouth bottle filled with the strongest liquor-ammonia, and covered with an inverted funnel, the tube of which passes through the center of the burner about two inches. The draught produced through the apparatus when the gas is burning is sufficient to cause a copious supply of ammonia vapor. Immediate combination ensues between the ammonia and the sulphur products of the consumed gas, and the liquid from the condensed vapors flows with the water of combustion into the receiver. During the combustion of the gas the following changes take place:— The hydrogen unites with the oxygen of the atmosphere and forms water; the carbon constituents of the gas also unite with oxygen and form carbonic acid; and the sulphur and ammonia combine and form sulphate of ammonia. The condensed liquid products of combustion, on being carefully collected, will be found to weigh about 350 grains for every cubic foot of gas consumed. Pure nitric acid is added to drive off the carbonic acid, the evolution of which is facilitated by the heat of a spirit lamp. A solution of nitrate of baryta, or chloride of barium, is then added in excess, and a white precipitate of the sulphate of baryta is immediately produced. After standing for some time, the supernatant liquor is carefully poured off, and the salt is collected on a counterpoised filter. It is then washed with boiling distilled water, dried, and weighed. Every 117 grains of sulphate of baryta so produced indicate the presence of 16 grains of sulphur, con-

sequently the quantity of sulphur in any form in 100 cubic feet of gas can be thus calculated.

APPENDIX B.

Referees' Sulphur Test—Originated by Gas Referees'—in use Since 1872.



The apparatus to be employed is represented above and is of the following description. The gas is burnt in a small Bunsen burner with a steatite top, which is mounted on a short cylindrical stand, perforated with holes for the admission of air, and having on its upper surface, which is also perforated, a deep circular channel to receive the wide end of a glass trumpet-tube. There are both in the side and in the top of this stand fourteen holes of five millimeters in diameter, or an equivalent air-way.

On the top of the stand, between the narrow stem of the

burner and the surrounding glass trumpet-tube, are to be placed pieces of commercial sesqui-carbonate of ammonia weighing in all about 2 ounces.

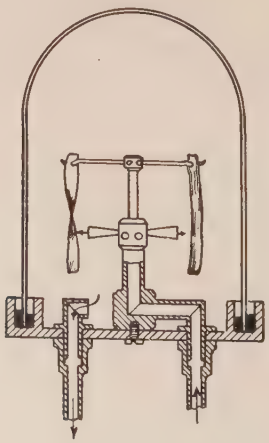
The products both of the combustion of the gas and of the gradual volatilization of the ammonia salt go upwards through the trumpet-tube into a vertical glass cylinder with a tubulure near the bottom, and drawn in at a point above this to about half its diameter. From the contracted part to the top the cylinder is packed with balls of glass about fifteen millimeters in diameter, to break up the current and promote condensation. From the top of this condenser there proceeds a long glass pipe or chimney slightly bent over at the upper end, serving to effect some further condensation as well as to regulate the draught and afford an exit for the uncondensable gases.

In the bottom of the condenser is fixed a small glass tube, through which the liquid formed during the testing drops into a flask placed beneath.

This liquid is then tested for sulphur in the usual way.

APPENDIX C.

Referees' Test for Sulphuretted Hydrogen in use from 1877 to 1906.



The gas shall be passed as it leaves the service pipe through

a small governor and thence through an apparatus in which are suspended slips of bibulous paper, impregnated with basic acetate of lead.

The test paper from which these slips are cut is to be prepared from time to time by moistening sheets of bibulous paper with a solution of one part of sugar of lead in eight or nine parts of water, and holding each sheet while still damp over the surface of a strong solution of ammonia for a few moments. As the paper dries all free ammonia escapes.

If distinct discoloration of the surface of the test paper is found to have taken place, this is to be held conclusive as to the presence of sulphuretted hydrogen in the gas. Fresh test slips are to be placed in the apparatus every day.

In the event of any impurity being discovered, one of the test slips shall be placed in a stoppered bottle and kept in the dark at the testing place; the remaining slips shall be forwarded with the daily report.

Gas passed 10 feet, automatically cut-off.

APPENDIX D.

Present Referees' Test for Hydrogen Sulphide—Originated in 1906.

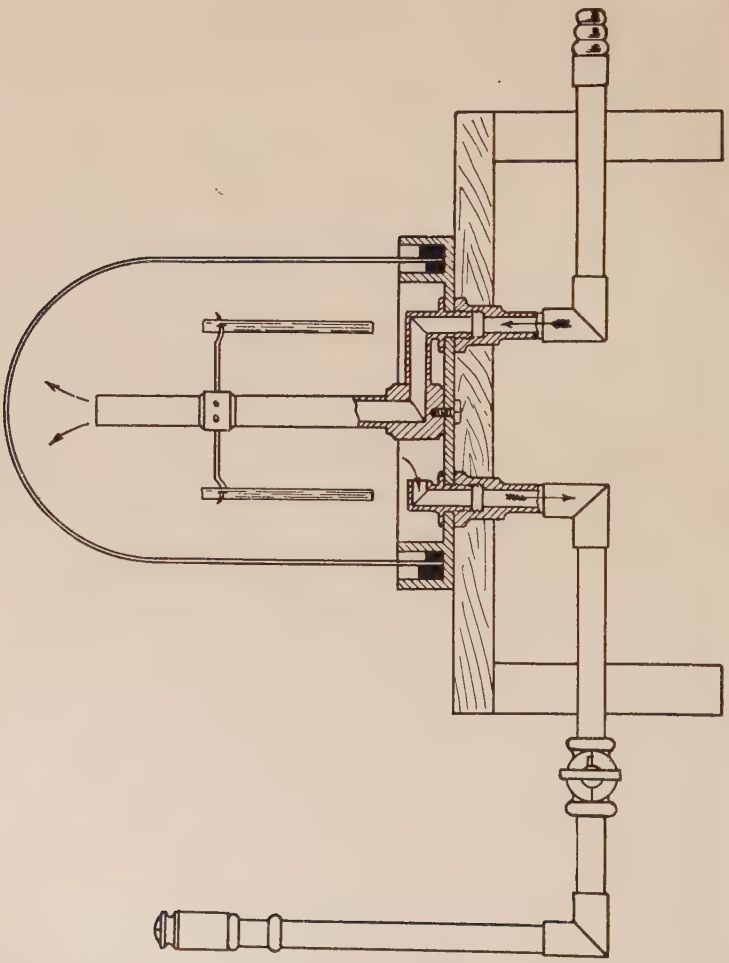
"The gas supplied by the Company shall not exhibit any trace of sulphuretted hydrogen when tested in a mode to be from time to time prescribed and certified by the gas referees for testing and recording the presence of sulphuretted hydrogen, which mode shall not be more stringent than the mode prescribed in Schedule A of the Gas Works Clauses Act, 1871." (London Gas Act, 1905, section 6).

The apparatus to be used in testing gas for the presence of sulphuretted hydrogen is represented above. The gas as it leaves the service pipe shall be passed through the glass vessel in which are suspended slips of bibulous paper which have been recently moistened by dipping them in a solution

consisting of 6.5 grams (100 grains) of crystallized acetate of lead dissolved in 100 cubic centimeters of water.

One testing shall be made daily.

In making the testing, gas shall be turned on to the ap-



paratus, and lit at the burner as soon as the air has been swept out. When the gas has burnt for three minutes it is to be turned off, and one of the slips of paper is to be compared

with another similar slip which has not been exposed to the gas. The gas is to be taken as exhibiting a trace of sulphuretted hydrogen if the slip of paper which has been exposed to it is unmistakably the darker of the two.

In this event two of the test-slips which have been exposed to the gas shall be placed in a stoppered bottle and kept in the dark at the testing place; one of the remaining slips shall be forwarded with each daily report, and the comparison slip shall be retained by the Gas Examiner for the use of the Chief Gas Examiner.

The Gas Examiner in making his return shall write either "present" or "absent" as the case may be.

APPENDIX E.

Method of Estimating H_2S in Gas—Hornby's Gas Engineer's Laboratory Handbook—Page 137.

The gas is slowly passed through an acid solution of cadmium chloride, contained in a couple of Woulff's bottles, and is then measured by means of an aspirator or meter. After passing a quantity of gas at the rate of about half a cubic foot per hour, the bottles are disconnected, and the precipitated cadmium sulphide is washed on to a filter; the contents of the filter are then placed in a beaker with distilled water, and bromine added in excess so as to oxidize the CdS to $CdSO_4$.

The bromine is driven off by heat, and resulting solution filtered and washed, the filtrate ($CdSO_4$) is then treated with an excess of $BaCl_2$ which precipitates $BaSO_4$. This is washed, dried, ignited and weighed in the usual manner.

Mr. Hinman: I have listened with much interest to this paper, I quite agree with him as regards the comparative innoxiousness of a trace of sulphuretted hydrogen, but there are some conclusions which I think are unwise. The author says: "At the present time in this country there are but four states and the District of Columbia where the amount of sulphur content is the subject of laws; namely, Wisconsin, Massa-

chusetts, Connecticut and New York. Following closely the old English laws, and probably somewhat blindly, the total sulphur permitted is 20 grains." I think the expression "somewhat blindly" is rather unfortunate. I am personally responsible for any legislation in Massachusetts that was passed on sulphur. The legislation was passed nearly 30 years ago, and I had been testing the gas of the principal companies of Massachusetts for some six or eight years. I found in such tests there was usually only about one-half of the 20 grains, namely, something like 10 grains. It did not seem to me it would work any hardship to limit the companies to 20 grains of sulphur. But that is a minor point.

The closing recommendation I think is inadvisable, namely, to allow one grain of hydrogen sulphide as a maximum in a 24 hour test. Now, in the states of Massachusetts and New York there are 60 to 100 companies that are subject to test, and if such a law as that was passed, the immediate effect would be that the number of inspectors would have to be increased, and it would make a lot of work for the inspectors.

Then as to the amount of sulphuretted hydrogen in gas I do not know just what the limit should be, but I think it advisable to limit it so that the gas is not offensive to the smell. I agree that it is entirely innocuous, except that it gives the consumer a chance to complain.

THE CHAIRMAN: Mr. Hinman, is that gas unburned or burned, which smells badly?

MR. HINMAN: Unburned. I think anybody whose opinion is worth anything agrees that sulphuretted hydrogen is no more offensive than carbon bi-sulphide, or any other sulphur compound when it is burned.

THE CHAIRMAN: Then, you consider that the odor of sulphuretted hydrogen in unburned gas is detrimental.

MR. HINMAN: It gives a chance for complaint, that is all. I do not consider it any disadvantage, other than that.

THE CHAIRMAN: The argument might be that the more offensive unburned gas is the better?

Mr. Hinman: Of course, that is so. I have found in my experience that consumers are perhaps unreasonable in that respect.

The Chairman: I have often heard it said that there is a strong odor from gas after being burned when there is sulphuretted hydrogen present. Of course, we know that there cannot be very much to complain of in that direction.

Dr. Elliott: I want to enter a protest against any such statement as that. I state most emphatically that foul gas burned in an open flame or in a Bunsen burner will be disagreeable in a room in which it is burned. I have tried it many times. Foul gas cannot be burned with any comfort in a room or in a house with the ordinary appliances.

Mr. Russell: I should like to ask Dr. Elliott what the offensive odor is due to. Why should there be a more offensive odor in the case of foul gas from hydrogen sulphide than with gas containing carbon disulphide or other sulphur compound? What is it due to?

Dr. Elliott: I cannot say any more than I can tell you that musk is offensive to some people and yet not to others. I venture to say that taking two rooms, one with thoroughly purified gas, burning in any appliance in the room, open flame or otherwise, and taking another room where the gas being burned is foul, you can tell the difference, unmistakably.

The Chairman: Foul from sulphuretted hydrogen, doctor?

Dr. Elliott: Yes.

Mr. Klumpp: Mr. Chairman, I cannot agree with Dr. Elliott in his statement that the sulphuretted hydrogen when burned creates a disagreeable odor, such an odor comes only through incomplete combustion. He stated that one grain of H_2S was detectable when present in gas, I doubt it. Ordinary illuminating gas contains usually ten to 20 grains of sulphur in shape of carbon bisulphide and other compounds and this he does not seem to detect when burned. Sulphuretted hy-

drogen burns to sulphur dioxide and water, while carbon bisulphide burns to sulphur dioxide and carbon dioxide. Both water and carbon dioxide are nonodorous, hence they both form in common sulphur dioxide, and as one grain of CS_2 forms nearly as much SO_2 as one grain of H_2S forms, I don't see how he is able to detect the quantity formed by the small amount of H_2S present. There is only one explanation to my mind, and that is that any disagreeable odor is caused by incomplete combustion of the gas.

Mr. Hinman: I had intended to add to my remarks that if any legislation was recommended by this Institute I would favor the Connecticut test as a practical one. It has been tried for some years, and it is my opinion that it is not unnecessarily severe, and it is fairly definite so that it will not be left open to some overzealous inspector, to unduly penalize companies, while it will still prevent any appreciable amount of sulphuretted hydrogen coming into the room.

Dr. Elliott: Will you please tell us what the Connecticut test is.

Mr. Hinman: It is to hold a piece of acetate of lead paper in the gas coming from an orifice one-thirty-second of an inch in diameter under an inch and a half pressure for the space of three minutes. As for having a scientific test for one grain or half a grain, it is stirring things up needlessly, making a whole lot of work for the inspectors and necessitating an increase in their number.

Mr. Russell: I think this is quite an important subject. The point is that the slight increase in the hydrogen sulphide does not cause in the burning any objectionable odor other than that due to sulphur dioxide, and I fail to see how it can, unless there is incomplete combustion, due to contact possibly with the metal surfaces of the burner or stove. We can better confine out attention to limiting the total amount of sulphur to a certain amount, and then we would not inconvenience the public any more; in fact, I think it would probably result in getting less sulphur compound into our gas,

and at the same time we would cheapen the manufacture to some extent.

THE CHAIRMAN: The cost of purification is most important; in fact, if you must have your gas so extremely free from sulphuretted hydrogen, you must put in a large investment to take care of the peak load on the purifiers which occurs only a few days a year. If the purifying system could be worked regularly, there might not be such a cause for complaint, but it seems unjust to the gas companies to require them to carry such a large purifying system that they may take out the very minute amounts of sulphur that appear yet, to my mind, to be innoxious to the consumer. Are there any other gentlemen who wish to be heard on this?

MR. RUSSELL: I should like to ask Mr. Fulweiler one question. He says, "It is a well known phenomenon that old oxide containing a large amount of free sulphur will remove a considerable amount of carbon disulphide." Have any tests been made along that line?

MR. FULWEILER: I will say I know that some tests have been made, but unfortunately I do not happen to have the data with me. I know that these tests have shown this to be the fact, and that it is probably due to the free sulphur in the oxide.

One thing I should like to ask Dr. Elliott is this: I wonder if Dr. Elliott's illustration was not particularly applicable when he said that the odor of musk is pleasant to some people and extremely unpleasant to other people, and if he has an exceptionally unpleasant sensitiveness to SO_2. I personally have it accentuated; I catch it at the back of my throat; that may be from smoking too much, but I am sure it is not H_2S, because I have burned gas showing considerable quantities of H_2S, and I did not notice any particularly disagreeable odor; I do not see how it is possible.

In regard to the inspecting proposition, you have a test now in most of the states and it would not be very difficult to show that that test allowed a certain fairly definite quantity

of hydrogen sulphur in the gas before it showed. Now, why does it necessarily increase the labor of inspection, if you increase that amount to some extent? It was shown very carefully that the Referee's test was sensible to 1/80th of a grain of hydrogen sulphide in a hundred cu. ft. of gas. Why does it make the labor any greater if you increase that to 1 grain? I do not see how you increase the labor at all, you simply increase the quantity.

Mr. McKay: In reply to the question by Mr. Russell as to the removal of CS_2 by free sulphur, in the course of some of our purification we have been able to remove one grain of CS_2 for every 66 grains of H_2S that was simultaneously taken out by the oxide.

In connection with the consideration of odor, I wish to supplement the statement by Dr. Elliott and to add that gas containing considerable quantities of carbon disulphide, 20 or 30 grains may be burned and in my experience, has been burned with no disagreeable odor resulting from such use of the gas; but similar gas carrying also a few grains of H_2S, when burned, undeniably contributes a disagreeable odor to the air in the room.

The Chairman: Have you any theory, Mr. McKay, as to what that is?

Mr. McKay: No. Much of the discussion has dealt with the gaseous products resulting from complete combustion; but the possibilities of incomplete combustion are forcibly realized under some conditions, and chemical equations will not then disclose the weight of unburned H_2S that may issue from designed or accidental apertures, burner openings or minute leaks.

Dr. Elliott: I think it fair to state that I noticed this when we first had sulphurous oils from Ohio. They had great difficulty in purifying those rank oils. I know at that time it was very troublesome, and then when they got better oils and had some method of taking the sulphur out of them, we could use them and get along.

Mr. Hinman: I think it a rather astonishing doctrine to say that it does not make much difference in the labor of inspection whether you qualitatively or quantitatively test. The ordinary test for sulphuretted hydrogen in Connecticut, Massachusetts and New York can be made inside of 5 minutes, and I think it is quite a different proposition from having a 24-hour test, and then on top of that a determination of the amount of sulphuric acid.

Mr. Fulweiler: I think I have already stated about all I have to say on the subject, except that, if you would have the rate of the passage of gas in the present Referees' test, taken only for, say a minute and a half, you would determine just about one grain in a hundred cubic ft. If I understand Mr. Ramsburg's paper, it was his idea that, for regular routine work, you would not have to go through a precipitation of cadmium sulphide, but by easily modifying the present methods that we have for testing gas, and making them a little less severe, we would simply raise the point at which the test showed to a figure which would approximate one grain. That could be done very readily by either shortening the time or by decreasing the rate of gas flow. You could retain all the old apparatus and the usual methods of making the test. For very accurate control of the work it would be very easy to use some form of precipitation test. By the way, I think there are several other methods of testing for H_2S which could be used, that would be rather easier than the cadmium sulphide test. That was simply suggested by Mr. Ramsburg.

The Chairman: The next paper is on the

Identification of Gas Oils, by F. E. Park and L. E. Worthing.

Mr. Worthing will read the paper.

A RAPID METHOD FOR THE IDENTIFICATION OF GAS OILS.

The following data have been gathered in an attempt to de-

velop a means of distinguishing between gas oils derived from different fields. While it is manifestly impossible for an ordinary laboratory to attempt to separate and determine the constitution of the numerous hydrocarbons of gas oils, a simple method of determining the type of oil at hand would often be useful.

From several standpoints a method of identification of gas oils seems desirable. A great deal of the data on water gas oil results is conflicting. This may possibly be due to a difference in composition of the oil used, a difference which could not be determined by ordinary tests. Some slight attempts have been made to determine the gas-making properties of various gas oils by small scale experiments, but the most reliable information on the values of gas oils for gas-making purposes is likely to be obtained from their actual use in water gas practice. Data collected from actual practice require a positive and simple method of identification of the oil in use, a method adapted to the average gas works laboratory. Such a method would aid in the interpretation of results collected from various sources, tend to explain discrepancies, and render results reported in gallons per thousand more intelligible.

Moreover, the most apparent application of a method of this kind is as an additional check on oil shipments. When water gas results fall off unexpectedly, it becomes important to discover if there has been a change in the quality of the gas oils. Specific gravity tests and fractionations do not throw a great deal of light on the subject, but further tests are usually dispensed with as they are expensive, tedious, and liable to be unsatisfactory. Luckily, to prove a change in the oil it is not necessary to determine its constitution. Any simple test serving to identify the oil is sufficient. It is proposed to use the bromine absorption number, which may be readily determined, for this purpose. Before proceeding to describe the process of bromination, it may be well to review briefly the chemical composition of petroleum.

Nature of Petroleum.

In defining petroleum, Mabery states: "Now after years of hard labor, I have reached the conclusion that petroleum from whatever source is one and the same substance, capable of simple definition—a mixture in varying proportions of a few series of hydrocarbons, the product from any one field differing from any other field only in the proportion of these series and number of the series."

Eight series of hydrocarbons, to each of which a generalized formula may be assigned, are found in petroleum ranging from the paraffins to the naphthalenes:

1.	C_nH_{2n+2}	Paraffins.
2.	C_nH_{2n}	Olefins and polymethylenes.
3.	C_nH_{2n-2}	Acetylenes
4.	C_nH_{2n-4}	Asphaltic hydrocarbons.
5.	C_nH_{2n-6}	Benzenes.
6.	C_nH_{2n-8}	Phenylethenes.
7.	C_nH_{2n-10}	Phenylethines.
8.	C_nH_{2n-12}	Naphthalenes.

These expressions, of which only the first five are important, are of use simply as a general classification of oils. Each one represents a group or series,—homologous, isomeric, or polymeric. In addition to the hydrocarbons, there are present, of course, a variety of related compounds containing oxygen, sulphur, and nitrogen. Such compounds, however, occur in small volumes as compared with the hydrocarbons.

The first formula, C_nH_{2n+2}, represents the paraffin hydrocarbons, of which the first member is methane, CH_4, and which ranges at least as high as $C_{35}H_{72}$. The paraffins are the most important of the open chain or aliphatic series. They are the principal constituents of Pennsylvania petroleum and have

been found in all petroleum except California.[1] Each member differs from the preceding one by CH_2. As the number of carbon atoms increases, the number of isomers (compounds having the same percentage composition but differing in the atomic arrangement) increases rapidly.

The liquid members follow:—

Name	Chemical formula	Melting-point	Boiling-point
Pentane	C_5H_{12}	.....	37°C.
Hexane	C_6H_{14}	.....	69
Heptane	C_7H_{16}	.....	98
Octane	C_8H_{18}	.....	125
Nonane	C_9H_{20}	—51°C.	150
Decane	$C_{10}H_{22}$	—31	173
Endecane	$C_{11}H_{24}$	—26	195
Dodecane	$C_{12}H_{26}$	—12	214
Tridecane	$C_{13}H_{28}$	.....	.....
Tetradecane	$C_{14}H_{30}$	+ 4	252
Pentadecane	$C_{15}H_{32}$	.....	.....
Hexadecane	$C_{16}H_{34}$	18	.....

To this must be added the isomeric forms, which differ slightly in boiling points and physical properties from the normal compounds.

C_nH_{2n} represents the composition of two important types of oils, first: the olefins or unsaturated open chain compounds, and, second: the aromatic closed ring compounds, the benzene hexahydrides, naphthenes, or polymethylenes,—as they are now usually called. The olefins are not as important a con-

[1] Mabery and Hudson, American Chemical Journal, April, 1901, p. 255.

stituent of petroleum as formerly supposed. In fact, they have only been positively identified in Canadian oil.[1]

The naphthenes or polymethylenes are notably present in Russian petroleum, in which they were first studied. Attention was drawn to them because of the similarity of their properties with the paraffins. They have since been identified as the predominate constituents of California and Texas petroleum, and are present in Ohio Trenton Limestone oil. Members of the series from C_7H_{14} to $C_{15}H_{30}$ were isolated from California crude.

The series C_nH_{2n-2} is called the acetylene series after its first member. The lower members, however, are never found in petroleum. Texas oils contain hydrocarbons of series C_nH_{2n-2} from $C_{14}H_{26}$ to $C_{19}H_{36}$. These hydrocarbons are characteristic of oil from Texas, Louisiana and Ohio. Compounds of this formula are certainly not all true acetylenes. The isomers can be explained by the assumption of two methylene rings connected as in the manner of diphenyl, with a sufficient number of side chains or connected carbon atoms between rings to account for the formula.

In oil from Trenton Limestone, Mabery and O. H. Palm[2] found hydrocarbons having the composition $C_{19}H_{36}$, $C_{21}H_{40}$, $C_{22}H_{42}$, and $C_{24}H_{46}$. With those compounds were members of the C_nH_{2n} series as high as $C_{17}H_{34}$. Texas oils contain the next series C_nH_{2n-4} from $C_{21}H_{38}$ to $C_{25}H_{46}$. This series also predominates in the heavy asphaltum oils from Louisiana.

There are probably oils of series containing much less carbon in the higher fractions of Louisiana and Texas oils, but decomposition on fractionation prevents separation necessary in order to study the pure compounds. The most promising method of getting at the constitution of these heavy hydrocarbons is by fractional filtration through Fuller's earth.

The series C_nH_{2n-6} represents the benzenes or aromatic hydrocarbons. Traces of benzenes have been found in nearly all oils, even in Pennsylvania oils. The lighter fractions of Cali-

[1] Mabery, Journal American Chemical Society, Vol. 28, p. 415.
[2] American Chemical Journal, Vol. 33, p. 251.

fornia oil, however, contain the largest per cent. of hydrocarbons of this series which includes, of course, the toluols and xylols.

1—Benzene	C_6H_6
2—Toluol	C_7H_8
3—Xylol	C_8H_{10}
4—Cumene	C_9H_{12}
5—Cymene	$C_{10}H_{14}$

Mabery and Hudson[1] in fractionating a California oil found 35% benzene in a fraction boiling near 80°C., in the 109 to 110°C. fraction 70% toluol, 135 to 140°C. fraction 75% xylol, and at 220 to 222°C. the distillate was solid with naphthalene. If there are any paraffins in California oil they occur in distillates below 70°C.[2]

Members of C_nH_{2n-8} and C_nH_{2n-10} series have also been identified in small amounts in California petroleum. The oil from the mid continental fields has a wide variation in composition and contains many different series.

Small quantities of oxidized compounds are found in petroleum, as acids and phenols. Phenols occur principally in California oils. Nitrogen is found in all oils and in the case of California oil, compounds of the formula $C_{12}H_{17}N$ to $C_{17}H_{21}N$ constitute from 10% to 20% of the crude petroleum. The nature of the sulphur compounds in petroleum if not well understood. It appears in many forms from occluded H_2S to so-called thiophanes. In Lima oil sulphur appears to be in the form of sulphides. Ten compounds from C_2H_6S to $C_{12}H_{26}S$ have been isolated.[3] Canadian petroleum in the higher fractions contain compounds of the formula $C_nH_{2n}S$[4]. Texas oil, besides organic sulphur, contains large amounts of free hydrogen sulphide.

Summarizing the characteristics of the principal American oils: Texas oil is remarkable for its asphaltic inert properties, Pennsylvania paraffin oil is even more chemically inert, Cali-

[1] Chem. Ind., 1900, p. 502.
[2] American Chemical Journal, April, 1901, p.255.
[3] American Chemical Journal, Vol. 13, p. 233.
[4] Proceeds American Acad., Vol. 41, p. 89.

fornia oil contains benzenes, and Canadian oil contains open chain unsaturated hydrocarbons. The other types have less striking peculiarities.

As gas oils usually are fractions of about 33° Baume, they contain not only a portion of the original oil, but are liable to contain products of decomposition caused by cracking. These decomposition products may cause the oil to exhibit properties —as it does indeed contain compounds—completely different from the original.

Process of Bromination.

The notion of treating hydrocarbon oils with bromine has been derived from the custom of identifying vegetable or animal oils by their so-called bromine or iodine numbers.

The idea of determining the amount of bromine an oil will take up is not a recent one, but dates back to 1857, to Cailletet, a Frenchman, who describes a method of treating oil with an alcoholic solution of bromine and titrating the excess bromine with a turpentine solution until the color is discharged.

In 1881, A. H. Allen proposed a method for brominating oil in which the bromine was liberated in contact with the oil by the decomposition of a water solution of sodium hypobromite with hydrochloric acid. Two years later Mills and Snodgrass proposed the use of carbon bisulphide as a solvent. These various schemes were all intended, principally at least, for the identification of vegetable or animal oils, which gave characteristic bromine absorptions, and for the detection of their adulteration.

The most satisfactory method involves the use of carbon tetrachloride as a solvent. This scheme was first used by McIlhenny[1] and is recommended principally because of the increased stability of the carbon tetrachloride bromine solution, and of a sharper end point in titrating. One of the reasons for the increased stability of the carbon tetrachloride over the carbon bisulphide can be inferred from a consideration of their boiling points.

1 Journal of American Chemical Society, Vol. 16, p. 275; Vol. 21, p. 1084.

Carbon bisulphide boils at 43° C.
Bromine boils at 63° C.
Carbon tetrachloride boils at 77° C.

Another is the fact that carbon bisulphide forms various sulphur bromides in solution and liberates free hydrobromic acid.

The method we have used is an adaption of McIlhenny's. Twenty-five c. c. of a tenth normal solution of bromine in carbon tetrachloride, previously standardized against sodium thiosulphate, is agitated with a quarter to half a gram of the oil to be tested in a stoppered Erlenmeyer flask. Before mixing, the sample of oil should be dissolved in 25 to 30 c.c. of carbon tetrachloride. The mixture is then allowed to stand in the dark for thirty minutes. The carbon tetrachloride solution and the oil to be tested should be previously dried by use of a few sticks of fused calcium chloride.

At the end of thirty minutes, about 100 c.c. of distilled water is added to the flask with 2 grams of potassium iodide, and the unabsorbed bromine titrated against a tenth normal sodium thiosulphate water solution. Starch solution is used as an indicator. The end point is reached when the bromine color of the oily layer has disappeared, and the iodine blue of the starch and water solution is just discharged. The oily carbon tetrachloride solution should appear red before titrating or insufficient bromine solution has been used.

The hydrobromic acid formed during the bromination is titrated against sodium thiosulphate by adding half a gram of sodium iodate to the flask, after the titration is finished, and titrating to the second disappearance of the blue color. Or, the hydrobromic acid may be titrated against N/100 caustic after separating from the oily layer. Better results can be obtained from the iodate method by first separating the oily layer from the water solution.

Both the absence of sunlight, and the careful drying of both oil and tetrachloride are most necessary, as light accelerates the bromination of the saturated compounds, giving rise to an undue proportion of substituted bromine; and the presence

of the smallest amount of moisture is even more effective in accomplishing the same result. The addition of the bromine solution and subsequent titration with sodium thiosulphate need not, however, be made under artificial light as by carefully duplicating the conditions of experiment, very concordant results may be obtained.

The total bromination number is the number of grams of bromine absorbed per hundred grams of oil. The bromine substitution number is the amount of bromine found as hydrobromic acid after the bromination is completed, calculated to the same basis. The bromine addition number is calculated by subtracting twice the bromine substitution number from the total bromination.

This calculation is based on the following equations:—

$$\underset{\text{(Ethylene)}}{2C_2H_4} + Br_2 = \underset{\text{(Ethylene Bromide)}}{2C_2H_4Br}$$

or,

$$\underset{\text{(Ethylene)}}{C_2H_4} + Br_2 = \underset{\text{(Ethylene di-bromide)}}{C_2H_4Br_2}.$$

Example of substitution:—

$$\underset{\text{(Toluol)}}{C_6H_5CH_3} + Br_2 = \underset{\text{(Hydrobromic acid)}}{C_6H_5CH_2Br} + HBr.$$

It is evident that for every substituted bromine compound formed, an equal amount of hydrobromic acid is formed. Hence, it is necessary to deduct both the bromine of substitution and the hydrobromic acid bromine from the total absorption to find the amount going to form addition products. Both the olefins and the acetylenes form addition products, so that in a general way it may be assumed that large addition numbers indicate acetylenes, olefins, or ring compounds with unsaturated side chains. Large substitution numbers—benzenes and small total bromination—paraffins or naphthenes. If paraffins were attacked by slight exposure to daylight, substitution products would be formed.

While it would not be fair to assume that the members of the different series are present in direct proportion to the

substitution, addition, or absence of bromination in the case of a single oil, between the various oils the results of bromination would indicate which oil contained more of a particular series.

The above described process was carried out on samples of oils differing largely in character and from widely separated fields. Through the courtesy of the St. Louis, San Antonio, Los Angeles, and Denver Gas Companies, and the Standard Oil Co., we received samples of gas oils of the principal types found in the United States. We also tested samples of Canadian crude.

Fractionations, sulphur content, heat values, and bromine absorption are given in Tables No. 1 and No. 2.

TABLE NO. 1.

Fractional Distillation.

Name	Specific gravity	Point of distillation	Up to 302° F.	302 to 572° F.	572 to 662° F.	662° up	Distillation loss
La Clede, St. Louis	31.7°B.	196°F	4.3%	30.7%	39.3%	20.7%	5.0%
	Spec. grav.:		59.2°B	38.7	30.7	26.2	Carbon
Denver G. & E. Co.	32.4	164	3.3	37.3	44.3	14.3	0.8
	Spec. grav.:		60.4	35.7	30.3	26.3	Carbon
Florence, Colorado	34.0	130	3.7	34.3	45.7	16.0	0.3
	Spec. grav.:		44.8	36.3	34.0	30.0	Carbon
Sugar Creek, Mo.	32.5	173	4.0	37.7	21.7	33.3	4.3
	Spec. grav.:		53.8	38.0	31.3	27.0	Paraffin
Florence, Col., No. 2	30.9	194	1.0	7.7	37.7	53.0	0.6
	Spec. grav.:			40.9	33.3	29.6	Carbon
Boulder, Col....	32.0	168	0.7	1.7	27.7	66.0	3.9
	Spec. grav.:				33.7	32.4	Paraffin
Canada, Crude ..	41.9	174	19.3	43.3	31.7	1.0	4.7
	Spec. grav.:		57.2	46.1	37.3		Pitch

Name	Specific gravity	Point of distillation	Up to 310° F.	310 to 475	475 to 570	570 to 690	690 up	Distillation loss
UTL. 11,831 D.C. Gas Co.....	34.4	211	7.3	29.3	21.3	32.7	8.3	1.1
Spec. grav.:			53.7	40.5	33.5	28.5	26.5	Carbon
San Antonio, Texas...	22.1	172	3.3 (1.7 water)	13.0	22.7	53.0	4.2	2.1
Spec. grav.:			51.3	35.1	27.8	23.9	Asphalt	carbon
Los Angeles, Cal.	20.1	218	5.7	15.3	12.0	33.7	21.3	10% asphalt 2% loss
Spec. grav.:			54.3	39.6	29.3	24.1	22.1	Carbon

TABLE No. 2.

Name	Specific gravity	Total bromination	Bromination substitution	Bromination addition	Sulphur	B. T. U.
D.C.G. Co. Utl. 11831	34.3	26.67	6.42	13.83	.26	18,867
San Antonio, Tex...	22.1	10.38	3.57	3.24	2.09	18,750
Los Angeles, Cal....	20.1	22.22	9.81	2.60	.80	18,538
Pennsylvania	34.4	11.20	2.99	5.22	.26	18,843
LaClede, St. Louis..	31.7	24.98	5.45	14.04	.56	19,526
Denver G. & E. Co...	32.3	10.70	2.58	5.54	.52	18,851
Florence, Colo.	34.0	5.48	1.48	2.52	.31	20,131
Sugar Creek, Mo. ..	32.4	16.41	4.46	7.49	.25	19,311
Florence, Colo., No. 2	30.9	14.15	3.37	7.41	.35	18,904
Boulder, Colo.	32.0	7.98	2.40	3.18	.28	
Canada Crude	41.8	4.87	.46	3.95	.50	
Pentane		0	0	0	0	
Toluol		2.80	1.40	0	0	
Benzol		0	0	0	0	
Xylol		6.34	2.43	1.48	0	

Pennsylvania oil, Florence, Col., Boulder, Col., and Texas oil appear to have a predominance of paraffins or naphthenes.

Detroit City Gas Co.'s oil and LaClede, St. Louis, oil seem to be largely olefins or unsaturated ring compounds, while Los Angeles oil is remarkable for the presence of benzenes, and Canada oil for the absence of them.

The proportionate large amount of additional bromination in the case of Canadian crude is further evidence of the presence of small amounts of olefins. The apparent presence of olefins or other unsaturated compounds in the Detroit City Gas Co.'s oil and in the LaClede is probably due to the cracking of the original oil.

Toluol shows exactly the theoretical substitution., Xylol, shows a preponderance of substitution, and some addition products probably due to impurities. Both these products, of course, belong to the benzene series.

The lack of action in the case of benzene is to be expected in the absence of carrier. It is readily brominated in the presence of certain foreign bodies which promote the action. The failure of benzene to react with bromine in a pure state indicates what an important effect a mixture of oils and the products of bromination may have on the amount of bromine absorbed.

To test the effect of mixing oils on bromine absorption, the Detroit oil and the San Antonio oil were mixed in exactly equal proportions by weight with the following results:—

By Test:—

Average total bromine absorbed	20.60
Average substitution	5.36
Average addition	9.88

Same by Calculation:—

Average total bromine absorbed	18.52
Average substitution	5.00
Average addition	8.53

Effect of mixing benzene and Florence oil:—

Average total bromine absorbed	4.91
Average substitution	2.12
Average addition	.68

By Calculation:

Average bromine absorbed	2.74
Average substitution	.74
Average addition	.63

It is apparent that the effect of increasing the number of constituents increases the amount of bromination. The total bromination of a mixture may then be assumed to be above figures calculated from bromination numbers of pure constituents.

Evidently, impurities in oil have the effect of accelerating slightly the bromination of hydrocarbons aside from their own action in absorbing bromine. Hydrogen sulphide is the impurity which probably causes the greatest error in interpretating the results of bromination, as it forms hydrobromic acid and free sulphur. If all the 2.09% of sulphur in San Antonio oil were hydrogen sulphide, the error would be 5.2 grams of bromine per 100 grams of oil, or sufficient to account for half the total bromination. However, in oils giving large bromine absorptions the amount of hydrogen sulphide present is nil, or negligible and the possible error due to its presence is very slight.

To test the value of the method in identifying a single type of oil, the following samples were brominated:

TABLE NO. 3.

Kind of oil	Car No.	Specific gravity	Total bromination	Addition	Substitution
Sta. A Utl.	11,831	34.4°B.	26.67	13.83	6.42
Sta. A Utl.	8,553	36.1	28.18	14.06	7.06
Sta. A Utl.	7,867	36.0	29.45	14.39	7.53
Sta. A Wks. Pump		36.1	31.35	16.03	7.66
Sta. B Utl.	8,513	33.6	32.07	15.33	8.31
Sta. B Utl.	7,545	33.6	33.07	14.54	9.23
Grand Rapids Utl.	9,405	33.0	27.18	9.54	8.82
LaClede, St. Louis		31.7	24.98	14.04	5.45

Grand Rapids and St. Louis gas oils are included in the above table only because they are all approximately of the same type. Detroit gas oil has the following average bromination numbers:—

Total bromination	Addition	Substitution
30.13	14.73	7.70

It varies from the average figure by +9.8% to —10.7%. Such variation would be expected in view of the range in specific gravity from 33.6°B. to 36.1° B. The Denver Gas Co.'s oil shows a striking similarity to the Pennsylvania gas oil, and, in turn, to the San Antonio gas oil, though the first two are undoubtedly largely paraffins and the last a polymethylene or naphthene.

An idea of the bromine values of oils which are published can be obtained from Table No. 4.

TABLE No. 4.

Oil	Specific gravity	Total bromination	Addition	Substitution	Authority
Shale	35.8°B.	48.2			Allen[1]
American Pet..	36.6	32.3			"
Russian Pet...	32.0	1.9	1.70	.10	"
Cal. Pet., Puente Field ..		18.8			Mabery[2]
Puente Field ..		18.3			"
Shale	33.5	22.24			Mills & Snodgrass[3]
Shale	31.9	20.59			"
Shale	28.0	12.59			"
Shale	26.0	11.72			"
Mineral	45.0	27.57			"
Illuminating ..	45.5	30.31			"

[1] Commercial Organic Analysis, Vol. 2, p. 95-25
[2] American Chemical Journal, April, 1901, p. 255.
[3] Journal Society Chemical Industry, Nov. 29, 1883, p. 366, 435.

The report of Mills and Snodgrass on shale oil in the above table shows that the absorption of bromine with shale oil varies inversely as the density of the oil.

Summary.

By treating gas oils with bromine dissolved in carbon tetrachloride, under specified conditions, a characteristic bromine absorption number can be obtained having an allowable variation of ± 10 % which may be used to identify the oil and serve as an additional check on the composition of gas oils, besides the specific gravity and fractionation tests. As an aid in distinguishing between saturated and unsaturated hydrocarbons, the amount of hydrobromic acid formed during the bromination is determined. The total amount of bromine absorption and the per cent. of hydrobromic acid formed are considered together in deciding as to the type of oil.

For purposes of water gas manufacture the method is exceedingly reliable and sufficiently accurate, and in the case of a single sample, the addition and substitution numbers may, by carefully duplicating the conditions of experiment, be checked to within 1/10th gram of bromine in every case. Two 50 c.c. burettes are the only apparatus required. About two hours are necessary for a duplicate determination.

The Chairman: Is there any discussion on this paper?

Mr. Fulweiler: There are several points relating to the practical application of the method discussed in this paper that I should like to have more fully explained.

In general I believe it will be found that commercial gas oils are mixtures of the varying distillates. Admitting now that in nearly all distillations more or less cracking occurs, and that this cracking masks or changes the character of the original oil, would figures furnished by the bromination test serve to identify the origin of the gas oil, or would not the fact that while in certain fractions of the crude oil we may have a preponderance of a definite series of hydrocarbons, which are characteristic of this oil, yet in making the mixture

that is sold as gas oil, might not these characteristics be either entirely lost or unduly prominent, so that for identification purposes the original characteristics would be destroyed? Again, many oils are blown with air or steam during the the distillation. Would not this seriously affect the bromination values of distillates secured in this way? If we grant that this method does recognize the preponderance of the members of a certain series of hydrocarbons, do the writers in their practical work in connection with this test feel that it will be possible to assign a figure of merit to oils which have characteristics indicating the preponderance of one of the hydrocarbon series? Or, in other words, which series of hydrocarbons yields the highest candle-power per gallon and what are the comparative merits of the different series? In connection with this point, I note that the Pennsylvania, Colorado and Texas oils seem to yield, approximately, the same bromination figures. Have the writers any data as to practical results which would seem to bear out this apparent similarity in composition?

In their paper they refer to the presence of the unsaturated olefins in the gas oil used in the Detroit city works, as indicating that the oil had been cracked in distillation. Do they conclude from this that in general all cracked oils will show unsaturated hydrocarbons, and is this in general the course which the hydrocarbons take in distillations at high temperatures?

Referring to the practical application of the test, have the authors found it necessary to run a check or blank determination along with the other samples, as is usual in carrying out similar tests, in order to prevent or detect errors due to adventitious local conditions?

Have the authors made any experiments with the sulphonation test to check up their results from this bromination test?

Mr. Park: In regard to oil, it is certain that cracking is a very large factor. Cracked oils absorb a great deal of bromin. When these oils are treated with sulphuric acid and

caustic until they are largely purified, it is found in subsequent brominations that the bromin absorption very largely decreases. The only point that can be taken to show the difference between oils is simply the figures we have already produced, which show that Texas and Pennsylvania oils do not have a large bromin absorption. In regard to the running of blank determinations, we ran some tests with xylol, benzine and various oils, which showed no bromin absorption whatever, which is sufficient to show that there is no error in the determination.

Mr. Fulweiler: Really, the principal inquiry I wanted to have answered was whether you had any practical figures which would seem to show that the oils which apparently contain a preponderance of one or more of these series gave better candle-power per gallon figures? That is, what is the per gallon application of it?

Mr. Park: We have accumulated no data on the relation between bromin absorption and candle-power.

The Chairman: The next paper is on

Power Plants for Gas Works of Medium Size,
by Mr. Chas. D. Robison.

Mr. Robison then read his paper as follows:

POWER PLANTS FOR GAS WORKS OF MEDIUM SIZE.

The development of the electric motor drive and the increased use of the gas engine has recently led to the installation of one, or both, of these types of motor in gas works, while at the same time steam engine drive has been retained in the same plant for certain purposes. In this paper the writer has tried to determine if, under certain specified conditions, either of these forms of drive are justified, and if they are the probable saving obtained by their use.

No original testing of apparatus has been attempted, but a thorough search has been made for reliable information in regard to the efficiency of the different machines that are used in both coal and carburetted water gas works. It would re-

quire too much space to mention all of the authorities used, but many of the figures have been taken from the paper read by Mr. Alten S. Miller, before the New York meeting of the American Gas Light Association, in 1899, and appearing in the report of the proceedings of that meeting.

As a basis of comparison, the cost of installation and operation of a power plant for a gas works having a maximum daily capacity of 2,000,000 cubic feet of coal gas, and 1,000,000 cubic feet of carburetted water gas, and an annual output of 480,000,000 cubic feet of coal gas and 240,000,000 cubic feet of carburetted water gas has been taken. A partial design for this plant was prepared so that the investment for the different types of installation could be determined, and the transmission losses calculated. In choosing a plant of this particular capacity, it was thought that the possibilities of economy on both larger and smaller plants would be clearly indicated. The steam consumption of the different steam-driven units was determined as follows:—

Three coal gas exhausters of a capacity of 1,000,000 cu. ft. per day would be required, one to operate constantly, and the other 200 days in the year, one being always in reserve. As not over 1.2% of the value of the steam is recovered in useful work, the number of cubic feet to be pumped makes little difference in the steam consumption of this apparatus. It should be stated that whenever the word efficiency is used in this paper, the efficiency on a heat basis is intended, that is to say, the heat equivalent of the useful work actually accomplished by the apparatus is compared with the total heat of the steam supplied to it to accomplish this work. Each machine would require while in operation 600 to 650 pounds of steam per hour, and on a basis of 600 lbs. of steam per hour would use approximately 8,200,000 lbs. per annum.

In Mr. Miller's paper it was stated that 10.8 lbs. of steam per thousand cubic feet of gas manufactured was required for operating pumps used in a carburetted water gas plant, and it is probable that about the same amount is required in a coal gas works. Theoretical calculations show about nine

pounds, and in this paper ten pounds of steam per thousand cubic feet of gas manufactured has been assumed.

The steam consumption of the scrubbers would be constant during operation, irrespective of the flow of gas through them. It was assumed that one machine would operate 8,760 hours and the other 4,320 hours in the year, and that the steam consumption would be 300 lbs. per hour.

The power required for operating the coal crushers and conveyors was determined, but no attempt was made to include the machinery necessary for placing and removing coal from storage, because it would vary so much in each installation.

The total power required for the crushers and conveyors would be 50 brake horse-power, with an average load of 40 brake horse-power five hours each day. A simple slide valve high-speed engine at this load would use about 60 lbs. of steam per brake horse-power per hour. The coke conveying machinery, coke elevators and screens, would require at full load 50 brake horse-power, and would operate six hours per day at an average load of 40 horse-power. The engine would be of the same type as the coal crushing engine, using 60 lbs. of steam per brake horse-power per hour. The combined charging and discharging machine would require a maximum of 20 horse-power and would average about 10 horse-power, while in use, which would be about seven hours per day. The type of engine used on this machine would require approximately 80 lbs. of steam per brake horse-power.

As there are about five pounds of ammonia produced per ton of coal carbonized, and as this is held in a liquor averaging about 1½% of ammonia by weight, there is approximately 330 lbs. of ammoniacal liquor produced per ton of coal carbonized. This liquor is concentrated from 1½% to 18%, consequently there will be about one-twelfth of the weight of the liquor raised to the boiling point and driven over as steam, say 27.8 lbs. The liquor supplied to the concentrator would have an average temperature of about 70°, and since 1,100 B. t. u. are required to raise water from 70° and turn it into

steam at atmospheric pressure, for that part of the liquor vaporized there would be required 27.8 × 1,100 = 30,580 B. t. u. The balance of the liquor would be heated from 70° to 200° requiring 130 B. t. u. per pound, or 305.2 × 130 = 39,676 B. t. u. This gives 70,250 B. t. u. as the amount of heat required to concentrate the ammoniacal liquor produced in the carbonization of one ton of coal. The waste from the concentrator is at about 120°, so for each pound of steam supplied for heating there are 1,050 B. t. u. available, on which basis 66.9 lbs. of steam would be required per ton of coal carbonized if the concentrator operated at 100% efficiency, but as the efficiency of this type of apparatus is not over 80%, 83.6 lbs. of steam should be supplied.

A test made in Philadelphia, Pa., on a 1,330,000 cu. ft. holder, reported in the proceedings of the American Gas Institute, page 682, Vol. 3, gives 100 tons as the total coal required for heating the holder and cups for one season. Correcting these figures for a climate more nearly representative of that existing throughout New England, New York, and the Middle States, and for the difference in capacity between this holder and the 2,500,000 cu. ft. holder required for this plant, the annual steam consumption would be 2,292,000 lbs. It is probable that heat would have to be supplied about 130 days in the average season, making the average hourly consumption 735 lbs. and the maximum 1,500 lbs. The amount of steam needed for heating the building was calculated from the size of the buildings. In extreme winter weather 40 B. t. u. per hour per square foot of exposed wall surface would be required, giving a maximum hourly consumption of 800 lbs. and an average of 400 lbs. for this purpose.

Condensation and leakage would vary greatly in each plant, due to the manner in which the piping was laid out and maintained. The amount of this loss shown in several tests varies from 8% to 15% of the output of the boilers. For the purpose of this paper I have taken 10% in each case, which is as low as would probably be obtained.

The steam consumption of the pumps used in a carburetted

water gas plant is taken at 8 lbs. per thousand cubic feet of gas made. Mr. Miller gives 10.8 lbs., but by selecting pumps designed for the work to be done, the lower figure should be ample.

The blower for this plant would require a 60 h.p. engine, which would operate one-half the time at three-fourths load, while the plant was in operation, which would be approximately 5,760 hours per year, giving 2,880 engine hours at three-fourths load. Under these conditions the type of engine that would be used would require about 2,700 lbs. of steam per hour or 7,776,000 lbs. per annum.

The exhauster in this plant would operate 5,760 hours, using 460 lbs. of steam per hour, or 2,650,000 lbs. per annum.

The steam consumption of the generator and oil heater were taken at the figures given in Mr. Miller's paper, 29.5 lbs., and 4 lbs. per thousand cubic feet respectively.

A maximum of 10 h.p. would be required to operate the tools in the work-shop. This engine would run about 2,200 hours in a year, and use about two-thirds of its full load requirements, or 400 lbs. of steam per hour while running.

In determining the boiler capacity that should be installed, a boiler horse-power has been taken as 34 lbs. of water turned into steam per hour. The maximum demand of each piece of apparatus was determined by calculating the maximum steam requirements over a period of thirty minutes, and dividing that by $\frac{34}{2}$. These results were totaled and one-third was added for reserve to allow for cleaning and repairs.

In visiting numerous gas works the writer has been impressed with the frequency with which freak types of boilers have been installed. A gas works is a poor place to work out experiments in boiler design, due to the small size of the boiler plant, the small proportion that the cost of boiler fuel bears to the other expenses of plant operation, to the relatively small amount of intelligent care given to this end of the business, and to the great variations of fuels that are used.

TABLE NO. 1.

STEAM CONSUMPTION WITH ALL STEAM DRIVE AND LIVE STEAM USED FOR ALL PURPOSES EXCEPT HEATING FEED-WATER.

Apparatus	Maximum steam consumption per hr. in lbs.	Average steam consumption per hr. in lbs.	Hours per year in which apparatus will be operated	Yearly steam consumption in lbs.	Boiler horse-power required	Price of engine including foundations and connections to machines	Cost of steam connections to engine
COAL GAS PLANT.							
3 exhausters, 1,000,000 cu. ft. daily capacity each	690	535	8,760	8,200,000	35.0	$1,050.00	$115.00
2 Standard Scrubbers	600	446	8,760	4,700,000	20.2	$1,050.00	$115.00
Pumps for all purposes	1,000	625	8,760	5,475,000	29.4	.....	100.00
Coal crushers and conveyors	2,400	2,400	1,820	4,380,000	70.5	1,800.00	60.00
Coke conveyors and screens	2,400	2,400	2,190	5,250,000	70.5	1,900.00	60.00
Charging and discharging machines	800	800	2,555	2,050,000	....	2,652.00	.....
Ammonia concentrator	2,400	2,400	1,675	4,012,000	70.5	.....	70.00
Holders (heating)	1,500	750	3,120	2,340,000	44.0	.....	.....
Buildings (heating)	800	400	3,120	1,250,000	23.5	.....	.....
Condensation and leakage (10%)	440	440	8,760	3,866,000	13.0	.....	.....
Totals for coal gas plant				40,747,000	372.0	$7,912.00	$520.00

TABLE NO. 1.—(*Continued.*)

Apparatus CARBURETTED WATER GAS PLANT.	Maximum steam consumption per hr. in lbs.	Average steam consumption per hr. in lbs.	Hours per year in which apparatus will be operated	Yearly steam consumption in lbs.	Boiler horse-power required	Price of engine including foundations and connections to machines	Cost of steam connections to engine
Pumps	360	330	5,700	1,920,000	10.1	$.....	$115.00
Blower engine	2,700	1,350	5,700	7,770,000	80.0	2,200.00	80.00
Exhauster engine	400	460	5,760	2,650,000	13.5	350.00	80.00
Generator	1,225	1,225	5,700	7,100,000	37.0	.....	180.00
Oil heater	170	170	5,760	960,000	5.0	.....	50.00
Condensation and leakage (10%)	334	334	5,700	1,930,000	0.8	.....	.....
To. of carburetted water gas plant			.....	22,330,000	155.4	$2,550.00	$505.00
Work shop	600	400	2,200	880,000	17.8	930.00	70.00
Condensation and leakage (10%)	.....	...	.....	110,000	0.4	.....	.....
Totals required for work shop	.....	...	.....	990,000	18.2	$ 930.00	$ 70.00
Total boiler horse-power for entire plant for all purposes	.....	...	.....	.....	545.0	.....	.....
Reserve boiler capacity required	.....	...	.....	.....	179.4	.....	.....
Total boiler capacity installed	.....	...	.....	.....	725.0	$10,875.00	$330.00
Yard connection, high-pressure steam lines only	.....	...	.....	.....	.....	.....	$4.490.00
Totals				64,073,000	725.0	$22,267.00	$5,915.00

Table No. 2.

Steam Consumption With All Steam Drive and Exhaust Steam Used for All Heating Purposes Wherever Available.

Apparatus	Maximum steam consumption per hr. in lbs.	Average steam consumption per hr. in lbs.	Hours per year in which apparatus will be operated	Yearly steam consumption in lbs.	Boiler horse-power required	Price of engine including foundations and connections to machines	Cost of steam connections to engine
COAL GAS PLANT.							
3 No. 6 Roots exhausters	1,200	930	8,760	8,200,000	35.0	$1,050.00	$300.00
2 Standard scrubbers	660	446	8,760	3,920,000	15.6	510.00	300.00
Pumps for all purposes	1,000	625	8,760	5,474,000	29.4	.....	200.00
Coal crushers and conveyors	2,400	2,400	1,820	4,380,000	70.5	1,800.00	250.00
Coke conveyors and screens	2,400	2,400	2,190	5,250,000	70.5	1,900.00	250.00
Charging and discharging machines ..	800	800	2,555	2,050,000	....	2,652.00	.....
Ammonia Concentrator	2,400	2,400	650	1,570,000	70.5	.....	100.00
Holders (heating)	.....	...	.....	.....	....	.....	.....
Buildings (heating)	.....	...	.....	.....	....	.....	.....
Condensation and leakage (10%) ...	370	370	8,760	3,046,000	10.8	.....	.....
Totals for coal gas plant				33,890,000	302.3	$7,912.00	$1,400.00

TABLE 2. (*Continued.*)

Apparatus CARBURETTED WATER GAS PLANT.	Maximum steam consumption per hr. in lbs.	Average steam consumption per hr. in lbs.	Hours per year in which apparatus will be operated	Yearly steam consumption in lbs.	Boiler horse-power required	Price of engine including foundations and connections to machines	Cost of steam connections to engine
Pumps	360	330	5,760	1,920,000	9.7	$.....	$250.00
Blower engine	2,700	1,350	5,760	7,776,000	80.0	2,200.00	200.00
Exhauster engine	460	460	5,760	2,650,000	13.5	350.00	200.00
Generator	1,225	1,225	5,760	7,100,000	37.0	.....	180.00
Oil heater	.....	...	.....	.....	....	.....	60.00
Condensation and leakage (10%)	310	310	5,760	1,790,000	9.2	.....	.....
To. of carburetted water gas plant				21,236,000	149.4	$2,550.00	$890.00
Work shop engine	600	400	2,200	880,000	17.8	930.00	180.00
Condensation and leakage (10%)	.....	...	.....	110,000	0.4	.....	.....
Totals required for work shop				990,000	18.2	$930.00	$180.00
Total boiler horse-power for entire plant for all purposes	.....	...	.....	.....	469.9	.....	.....
Reserve boiler capacity required	.....	...	.....	.....	142.8	.....	.....
Total boiler capacity installed	.....	...	.....	.....	625.0	$9,375.00	$330.00
Yard connection, high-pressure steam and exhaust lines	.....	...	.....	.....	....	.....	6,590.00
Totals				56,116,000	625.0	$20,767.00	$9,390.00

From considerable personal experience, and from conversations with many men employed in boiler-house work, it appears that some standard form of water tube boiler in the great majority of cases, is the best steam generator to use. This is due to the great overload capacity of this type of boiler, and to the probability that they will be kept cleaner than other types, owing to the ease with which scales in the tubes can be detected, as compared with other kinds of boilers. The cost of boilers in units of 200 h.p. is taken at $15 per horse-power erected, including ordinary foundations and steel stacks.

Table No. 1 is prepared in conformity to the foregoing and Table No. 2 is the same as Table No. 1, except that all exhaust steam available has been used for heating and credited at the rate of 70% of the value put into the engine. The cost of piping and engines given in Tables Nos. 1 and 2 was taken from recent quotations. The piping is all high grade work, and when placed inside of the buildings is covered with magnesia covering, and when placed outside, laid underground in wooden logs.

In calculating the steam required for motor-drive a steam consumption of 40 lbs. per kilowatt hour of net station output, using a compound non-condensing engine, has been taken. The transmission and motor losses would not exceed 18%, giving a steam consumption of 48.7 lbs. per kilowatt hour, equal to 36.2 lbs. per horse-power hour delivered at the end of the motor shaft. Before discussing the steam consumption of the different apparatus electrically driven, it would be well to take up the characteristics of the current supplied. The advantage of direct current over alternating current is that variable speed direct current motors can be supplied to give almost any range of speed required, while only two or three variations are practicable with alternating current motors, but as the regulation of the direct current motors is not close enough to be used for coal gas exhausters without also using a compensator to regulate the gas, and as all classes of coal handling machinery and charging machines are now made when required to be driven by alternating constant

speed or two speed motors, this advantage is not great. On the other hand, the danger of fire or explosion from sparking which is constant and unavoidable in the direct current motor, is entirely removed when certain types of alternating motors are used. The difference in cost is slightly in favor of the direct current motor, but this is more than compensated for by the lower maintenance charges against the alternating current type. In the present state of development there is no reason why the entire plant should not be driven by alternating current motors. Having decided on alternating current the phase and alterations to be used must be determined. Two-phase has no advantage over three-phase current, and does not lend itself as readily to two speeds, while the cost of wiring is somewhat greater. 60-cycle current is better adapted for lighting than any having fewer alternations, but slow-speed motors of this type are very large for the power developed, and in the small sizes are all special motors. With 25-cycle current the lighting would be poorer, but would answer perfectly every purpose about a gas works, and as the demand is for slow-speed motors, which can be supplied as standard and at much lower cost for 25 than for 60-cycle current, this number of alternations has been selected.

There are no advantages to be gained where the distance covered is as small as in this plant that would compensate for the dangers entailed by the use of high voltage current. The cost of wiring would be less with 2,200 volts than with 220 volts, but the precautions to be taken to make the higher voltage safe, and the cost of transformers to step it down for use in the motors, or the additional cost of high voltage motors, and, more than anything else, additional danger to life and property, would indicate that low voltage should be used. Consequently the current best adapted for this use seems to be 220 or 440-volt, three-phase 25-cycle alternating. When electric drive has been previously advocated, objections have been raised to the danger of explosions due to its use. With a non-sparking type of motor, all wiring installed in pipe conduits, and the switches and fuses placed outside the building,

it is hard to believe that any arcing would take place, and if by any chance it should occur, that it would be coincident with the presence in the room of an explosive mixture. Objections have also been raised to the use of motors on coal gas exhausters, because of the difficulty in regulation. In at least one plant constant-speed motors have been used for driving the exhausters for some years, and by using a compensator on the gas, the pressure on the hydraulic main has been mantained as uniform as in any steam-driven plant.

In view of the foregoing, if the use of the electric drive shows a saving, there is no reason why it should not be used.

The steam required to be generated to supply the power to operate the electric motors, driving the different apparatus, was estimated as follows:

One of the exhausters would be in use twenty-four hours a day, for 365 days in the year; the other would be operated at full speed 90 days, and one-half speed 110 days, making 12,240 hours. Six horse-power is required to drive the exhauster at full load, consequently 73,440 h.p. hours per year will be used. The consumption of steam per horse-power being 36.2 lbs., the annual steam required for this purpose is 2,660,000 lbs.

The scrubbers would operate as stated in the foregoing, 13,080 hours in a year, and require 3 h.p. per hour, making the steam requirements 1,420,000 lbs. per annum.

In calculating the steam required for pumping, the efficiency of the pumps is taken as 2%, which would give a steam consumption of 112 lbs. of steam per equivalent of 1 brake horse-power delivered for useful work in raising water. The total mechanical efficiency of a combined pump and motor is about 60%, and as the efficiency of the motor is 85%, the power delivered at the end of the engine piston is 85/60 of 2%, or 2.83%; as the efficiency of the motor-drive to the end of the motor shaft is 6.2%, then the stream required for motor-driven pumps is $\frac{283}{620}$ of that required for individual steam engine drive, or 2,520,000 lbs.

As 25% was added to the power required by coal crushers and coal conveyors to cover loss in belt and gear transmission, which would be saved by motor-drive, the steam consumption would be $\frac{4{,}380{,}000 \times 0.75 \times 36.2}{60} = 1{,}985{,}000$ lb. The requirements of the coke handling machinery are calculated in the same manner.

The steam used in the charging machine will be in the proportion that the steam consumption per horse-power with motor, bears to that with the engine drive, namely $\frac{362}{800}$.

All of the heat of the exhaust steam will be required for heating buildings and holders for 130 days. During the balance of the year at least one-half of the steam required for ammonia concentration will be furnished from the engine exhaust.

The steam consumption of the motor-driven pumps and exhauster for the carburetted water gas plant is figured in the same manner as that for the same apparatus in the coal gas works. The steam required for the carburetted water gas blower is $\frac{362}{600}$ of that required for the engine drive.

The work shop would require 10 h.p. in motors, and as in a shop of this nature the average hourly use of the entire connected load does not average over 750 hours per year, the steam required for motor-drive would be $750 \times 10 \times 36.2 = 271{,}000$ lbs.

The engine horse-power required was determined by dividing the sum of the maximum hourly demand of steam for motor-drive, as shown in Table No. 3, by 36.2. The quotient is 150. To guarantee continuity of service this should be in duplicate; two engines of 150 h.p. each.

Alternating current generators are usually rated for capacity at 90% power factor, and as the power factor of this plant will probably be not over 75%, the capacity of the generator should be $\frac{90}{75}$ of the engine capacity. All steam requirements

Table No. 3.

Steam Consumption With Non-Condensing Central Station for Generating Electricity, All Apparatus Operated With Motor-Drive, Exhaust Steam Used for Heating Purposes Wherever Available.

Apparatus	Maximum steam consumption per hr. in lbs.	Average steam consumption per hr. in lbs.	Hours per year in which apparatus will be operated	Yearly steam consumption in lbs.	Boiler horse-power required	Price of motor including foundations and connections with machines	Cost of steam connections to engine
COAL GAS PLANT.							
3 No. 6 Roots exhausters	434	294	8,760	2,660,000	12.7	$ 970.00	$205.00
2 Standard scrubbers	191	162	8,760	1,420,000	5.6	286.00	205.00
Pumps for all purposes	384	288	8,760	2,520,000	11.3	810.00	300.00
Coal crushers and conveyors	1,100	1,100	1,820	1,980,000	32.0	930.00	175.00
Coke conveyor and screens	1,100	1,100	2,190	2,380,000	32.0	663.00	175.00
Charging and discharging machines ..	365	365	2,555	930,000	9.5	1,815.00	800.00
Ammonia concentrator	2,400	2,400	1,180	2,840,000	70.0	.....	.....
Holders and buildings, (heating can all be accomplished from exhaust steam	.....	...	.....	.....	....	.....	.....
Condensation and leakage (10%) ...	200	200	8,760	1,680,000	5.9	.....	.....
Totals for coal gas plant				16,410,000	179.0	$5,474.00	$1,860.00

TABLE NO. 3.—(*Continued.*)

Apparatus CARBURETTED WATER GAS PLANT.	Maximum steam consumption per hr. in lbs.	Average steam consumption per hr. in lbs.	Hours per year in which apparatus will be perated	Yearly steam consumption in lbs.	Boiler horse-power required	Price of motor including foundations and connections with machines	Cost of steam connections to engine
Pumps	206	153	5,760	883,000	6.0	$1,204.00	$240.00
Blower	1,800	814	5,760	4,690,000	54.0	1,200.00	100.00
Exhauster	217	217	5,760	1,250,000	6.4	660.00	100.00
Generator	1,225	1,225	5,760	7,100,000	37.0	.....	.....
Oil heater	.....	...	.....	.....	....	.....	.....
Condensation and leakage (10%)	239	239	5,760	1,357,000	17.0	.....	.....
To. for carburetted water gas plant				15,280,000	120.4	$3,064.09	$440.00
Work shop	360	123	2,200	271,000	10.4	480.00	100.00
Condensation and leakage (10%)	.....	...	.....	31,000	1.6	.....	.....
Totals required for work shop				302,000	12.0	$ 480.00	$100.00
Total boiler horse-power for entire plant for all purposes	.....	...	.....	.....	311.4	.....	.....
Reserve boiler capacity required	.....	...	.....	.....	103.6	.....	.....
Total boiler capacity installed	.....	...	.....	.....	415.0	$6,325.00	.....
300 h. p. generating plant	.....	...	.....	.....	....	26,200.00	.....
Yard connection, high-pressure and exhaust steam piping & conduit system	.....	...	.....	.....	.....	.....	$8,500.00
Totals				31,992,000	415.0	$41,543.00	$10,900.00

in Table No. 3 were calculated in conformity to the foregoing, and all costs of installation are from quotations on material worked out in detail.

This plant would carbonize approximately 48,000 tons of coal per year, and produce 21,600 tons of coke for sale, of which 5%, or 1,080 tons, would be fine dust having no market value, and 10%, or 2,160 tons, would be fine coke having a market value of about $2.50 per ton in the yard, making this fuel worth $5,400. This material mixed would vaporize about 4 lbs. of water per pound of fuel under usual operating conditions. The annual boiler room expense of the different plants would be as follows:

TABLE No. 4.

	Plant with individual steam units in which exhaust is lost	Plant with individual steam units in which exhaust is utilized	Plant with motor-drive utilizing exhaust
Lbs. of steam required per annum	64,073,000	56,116,000	31,992,000
Lbs. of steam produced from breeze ...	25,920,000	25,920,000	25,920,000
	38,153,000	30,196,000	6,072,000
Lbs. of coal required.	5,450,000	4,300,000	870,000
Long tons	2,440	1,920	372
Cost per ton delivered in boiler room	$3.50	$3.50	$3.50
	$8,525	$6,720	$1,300
Value of coke burned	5,400	5,400	5,400
Total cost, boiler fuel	$13,925	$12,120	$6,700
Water at 10c. per 1,000 gals.	700	605	378
Firemen labor	3,000	3,000	2,000
Supplies and cleaning	500	500	275
	$18,125	$16,225	$9,353

The total charges per year against the different plants are shown in Table No. 5.

TABLE No. 5.

	Plant with individual steam units in which exhaust is lost	Plant with individual steam units in which exhaust is utilized	Plant with motor-drive utilizing exhaust
Investment for individual motors	$11,392	$11,392	$ 9,018
Investment for boiler capacity required in each case.	10,875	9,375	6,325
Investment for pipe or wire connection	5,915	9,390	10,900
Investment for power house and equipment	.....	.....	26,200
Total investment for steam supply and motive power	$28,182	$30,157	$52,443
Depreciation	.04	.04	.04
Annual charge for depreciation	$ 1,125	$ 1,206	$ 2,097
Operating charges as shown in Table No. 4	18,125	16,225	9,353
Annual charge for steam supply and motive power	$19,250	$17.431	$11,450

From the foregoing it will be seen that by an investment of $2,000 for equipment to utilize the exhaust steam to the fullest extent for heating $1,819 per year will be saved, and that the investment of $22,300, which is the excess in cost of an electrically-driven over an engine-driven plant, will save $6,872 per annum. If a new plant is being erected so that this saving would be applicable for interest on the difference in cost between the two types, earnings of 31% are made, but if the plant is already built and the present equipment must be abandoned, causing depreciation to accrue on the cost of both plants, and interest charges on the entire cost of the electric plant, a saving of only 6.8% on the investment is earned.

In English and European practice, gas engines are often used to take the place of individual steam engines on such

apparatus as coal and coke handling machinery and the carburetted water gas blower, and occasionally this type of prime mover is used for driving the generators that supply the electricity for the entire plant. No attempt was made to work out figures to show whether there would be any saving by their use, but by calculating the total hours' use of each engine in each year, and using curves prepared about two years ago by the writer from actual quotations and operating costs of both gas engine and steam engine plants, there is apparently no justification for the use of gas engines in any part of this works. This is due to the poor load factor under which the engines would operate, that is to say, the small number of hours that the engine operates at full load during the year, which condition is fatal to economy in gas engine practice, and is also due to the large amount of exhaust steam that can be utilized to advantage for heating and ammonia concentration.

In concluding it might be interesting to note that a coal gas works fully equipped with machinery and electric-drive requires a trifle over 0.12 h. p. of boiler capacity per 1,000 cubic feet of maximum daily output, while the same plant, steam-driven, requires 0.2 h. p., and a plant of the same capacity steam-driven without any labor-saving machinery would require 0.12 h. p. In a carburetted water gas works a plant designed for motor-drive would require 0.16 h. p., and with engine-drive 0.2 h. p. per 1,000 cubic feet of maximum daily capacity.

Mr. Dewey: Mr. Robison's paper on "Power Plants for Gas Works of Medium Size" contains some figures and deductions that seem incorrect and not to correspond with the usual operating practice. A No. 9 Roots exhauster turning over 54 R. P. M. and pumping against a differential pressure of 27" and handling coal gas direct from the hydraulic main will show an indicated H.P. of about 11. It would, therefore, not be out of the way to estimate 10 H.P. per exhauster and it would not seem too high to place the steam used per hour per H. P. at 60 lbs. in a machine of this type.

The Holmes Rotary Scrubber, capacity of 1,500,000 cu. ft. per day, will use approximately 3.4 H.P. in turning 4 R.P.M. and 60 lbs. of steam per H.P. hour should be taken for this. Regarding the amount of steam used for the operation of the ammonia concentrator, no account was taken in the figures given of the lime water or pumps necessarily a part of the concentrator. We have made some tests on a 6-foot concentrator running something over 1,000 gallons of 1.8 per cent. crude liquor per hour and find that the steam consumption for concentrating the liquor from 2,000 lbs. of coal will run about 170 lbs. Therefore, I would revise Table No. 1 as follows:—

Coal gas plant apparatus	Steam consumption per hr. in lbs. max'm,	Av'ge.	Hrs. per yr. in which apparatus will be operated	Yearly steam consumption
3 exhausters, 1,000,000 cu. ft. daily cap. each	.....	.....	.....	8,136,000
2 Standard scrubbers	.....	.....	.....	4,891,920
Pumps for all purposes	1,000	625	8,760	5,475,000
Coal crushers and conveyors	2,400	2,400	1,820	4,380,000
Coke conveyors and screens	2,400	2,400	2,190	5,250,000
Charging and discharging machines	800	800	2,555	2,050,000
Ammonia concentrator, 170 lbs. per ton (2,000 lbs.)	2,400	2,400	1,675	8,160,000
Holders (heating)	1,500	750	3,120	2,340,000
Buildings (heating)	800	400	3,120	1,250,000
Works water pump	.....	.....	.....	8,660,000
Heating tar tanks	.....	.....	.....	5,000,000
Condensation and leakage (10%)	440	440	8,760	5,512,920
Total for coal gas plant				61,105,840

CARBURETTED WATER GAS PLANT.				
Pumps	360	360	5,760	1,920,000
Blower engine	...	...	.....	8,064,000
Exhauster engine	...	...	.....	3,478,000
Generator	...	...	.....	9,600,000
Oil heater	170	170	5,760	960,000
Condensation and leakage (10%)	...	...	.....	2,421,200
Total				26,443,200
Work shop	600	400	2,200	880,000
Condensation and leakage (10%)				110,000
Total				990,000
Grand Total				88,539,040

You will note I have figured, in calculating the steam consumption for the exhausters (first item, Table No. 1) 10 H.P. $\times$ 60 (steam consumption per hr.) $\times$ 13,560 (total hours of operation for both exhausters). The same applies for the scrubbers.

Under carburetted water gas plant, I have taken 35 H.P. as the necessary horsepower for operating the blower engine and the steam consumption for this engine should not exceed 40 lbs., as it is run at about full load and is a high-speed engine and should be equipped with a fly-wheel governor. Steam used in the generator I have materially changed, ordinary practice demands about 36 to 40 lbs. steam consumption per M. feet of gas made when coke is used. This means a total annual steam consumption for both coal gas and water gas plants of 88,539,040 lbs., which is about 24,000,000 lbs. more than Mr. Robison has given in his paper.

In figuring up steam consumption in Table No. 3, using the electric drive, only 6 H.P. has been taken to drive the exhausters. Just why it will take less horsepower with the motor-drive than steam-drive is not clear. Driving the ex-

hausters with motor, as is proposed to do, demands that the power required at the maximum load must be operated continuously. Inasmuch as the peak load will run from 15 to 20 per cent. above the average, it would mean that that much greater power would be required throughout the entire period. I have, however, taken 10 H.P. per exhauster.

Table No. 3 should be changed as follows:—

Coal gas plant apparatus	Steam consumption per hr. in lbs. Max'm.	Av'ge.	Hours per yr. in which apparatus will be operated	Yearly steam consumption
3 No. 6 Roots exhausters	434	294	.....	4,881,600
2 Standard scrubbers	.....	.....	.....	1,644,320
Pumps for all purposes	384	288	8,760	2,520,000
Coal crushers and conveyors	1,100	1,100	1,820	1,980,000
Coke conveyor and screens	1,100	1,100	2,190	2,380,000
Charging and discharging machines	365	365	2,555	930,000
Ammonia concentrator	2,400	2,400	1,180	8,660,000
Heating tar tank	.....	.....	.....	5,000,000
Condensation and leakage (10%)	200	200	8,760	2,749,592
Total for coal gas plant				30,745,512
CARBURETTED WATER GAS PLANT.				
Pumps	206	153	5,760	883,000
Blower	1,800	814	5,760	7,317,920
Exhauster	217	217	5,760	2,073,600
Generator	1,225	1,225	5,760	9,600,000
Condensation and leakage	239	239	5,760	2,000,000
Total for carburetted water gas plant				21,874,520

Work shop	360	123	2,200	271,000
Condensation and leakage				31,000
Total required for work shop				302,000
Totals				52,922,032

This makes a total of 52,922,000 lbs. steam consumption with electric-driven motors. This would materially alter the calculations throughout the paper and necessarily reduce the percentage of savings, although the total reduction in the amount of steam used per annum would be about the same.

An interesting sidelight on the amount of steam required to actually operate a plant compared with the amount required in the hypothetical one taken in the paper, for the year 1908, is as follows:—

Total coal gas made	473,364,000 cu. ft.
Water gas made	298,168,000 cu. ft.
Total	771,532,000 cu. ft.

The total steam consumption, figuring back from the coal used and taking the evaporation as 8 lbs. for coal, and 5 lbs. for coke, gives us 88,400,000 lbs., or 115 lbs. of steam per M. feet of gas made. This coal gas plant has charging and discharging machines, coal handling apparatus, coke elevators, ammonia concentrators, etc. It is in most every way a modern type of coal gas and water gas plant. There are, however, nothing but simple non-condensing engines throughout the plant. You will note that it checks very closely with the figures I have given in the revised tables, the steam consumption being about 117 lbs. per M. feet of gas made.

Mr. Klumpp: Mr. Chairman, I think some of the figures in this paper that Mr. Robison has assumed on steam consumption are very low, and I agree with Mr. Dewey. He cannot get below 60 or 70 lbs. of steam per kw. hr., if he is going

to put in an electric-driven plant. I see no reason why we cannot adopt a gas engine. At holder cost for the gas used he would realize great economies. He speaks of the practice in the past of not using gas engines. Of course, if he was talking of installing half a dozen small gas engines in various parts of the works, he would not get these economies, but with a single large unit it should be considered within the last five years gas engines have been greatly improved and if anyone is considering putting in an electric-driven plant, by all means figure also on gas engines. because you can get economies with your gas—at holder cost. It has been said by some persons who put in gas engines that their repairs have been very high, in the past, this may be so but gas engine repairs to-day are getting as low as steam engine repairs, and the gas engine is just as reliable.

Mr. McKay: In table No. 1 for water gas manufacture the largest single item of steam consumption is driving the blower, which figures out at 32 lbs. per thousand ft. of gas made. Perhaps the author considered a volumetric blower in that estimate. Our experience with blowers is that probably not more than 11 or 12 lbs. of steam per thousand ft. of gas made need be used in blowing air through the generators, and I speak of this in order to emphasize the possible economy that may result from substituting the positive type for the volumetric type of blower.

Mr Brown: Mr. Chairman, commenting on Mr. Dewey's discussion, I think Mr. Dewey would be the last one to say that he would put a 10 H. P. engine on an exhauster. I think, when we are considering the average working conditions, in works of that size, that we must figure that the man who is wise in putting in the ordinary solid valve type of engine would make it big enough so that while his steam pressure might be assumed at 125 lbs., he would be able to operate at 80 lbs. If he did not he would perhaps gain a theoretical economy by putting in an engine just big enough to operate, but he would lose in reliability. I do not think

any of us would choose between the two; we would gain reliability at whatever the cost. On the question of steam consumption I think, if we took actual tests in a great many works of this size that we know of, we would find Mr. Robison's figures under rather than over. I realize that there is a great deal in what Capt. McKay says as to the possibilities of economy through using positive blowers, but in the past it has been a pretty difficult thing to use positive blowers, because of the great relative differences in discharge required to operate water gas machinery. I think Capt. McKay might have added, that the way he has been able to use positive blowers is through a special form of governor which they have developed, which perhaps the rest of us are not familiar with.

Mr. Bates: I am not sure whether the author concludes that the use of 25-cycle 3-phase motors is desirable or not, but I think it is very essential that that should be given careful consideration. While it is true that the 25-cycle motor is a low speed motor, a small 25-cycle generator is difficult to obtain. A 60-cycle can be readily obtained from your electric light man for breakdown service. I think also there is some doubt as to whether 3-phase should always be taken. It may well be that 2-phase is desirable for the same reason. As far as 25-cycle lighting is concerned that is at present good enough, as you know. There are many thousand incandescent lamps of 25-cycles used in Buffalo, and the elevated stations in New York are all so lighted.

The Chairman: Mr. Robison, will you close the discussion?

Mr. Robison: In regard to the size of the exhauster engines, I figured out the actual horse-power that would be required, and figured on 12½ horse-power engines, with a steam consumption of 100 lbs.

In regard to the gas engine suggested in the paper, I did not try to work out, at this particular time, the possible economies in this kind of prime mover, but some time ago when I did

work it out pretty carefully I found the estimate of operating at less than 50 per cent. of the load factor and the high cost of the engine, did not make it look very promising. I intended to work that out in more detail, but the paper became too long, and I did not go into it.

In regard to criticism of the cycles used I considered the possibility of buying current from the local electric light company having a breakdown connection, and the possibilities of using the 60-cycle 2-phase current, but my own experience and considerable talk with men, who have devoted all their time to that particular branch of the business, led me to believe that, for the reasons given in the paper, the large size of the 60-cycle motors as compared with the 25-cycle and the difficulty of getting a variable speed on the 2-phase 60-cycle, led me to recommend the use of the type of current that I did.

MORNING SESSION, OCTOBER 21ST, 1909.

COMMERCIAL SECTION.

The meeting of the Commercial Section was called to order by the Vice President, Donald McDonald, of Louisville.

THE CHAIRMAN: I will appoint Mr. Clabaugh Secretary of this meeting.

Mr. George W. Thomson will please read his paper on

GAS IN THE MODERN KITCHEN.

GAS IN THE MODERN KITCHEN.

To install successful modern kitchens, a study of local conditions is essential. The most important is the amount of fire carried in the fire box of the furnace, as on this depends somewhat the location of the proposed coil as well as the success of the equipment. To maintain the kitchen at a temperature of seventy degrees in zero weather by means of a coil in furnace, requires the upkeep of an average furnace fire; this does not mean that you would have to use additional coal on account of the coil, but both heat and hot water cannot be guaranteed where only slow or small fires are run. In many cases,

though, the coil in slow fires will supply the hot water for domestic purposes, and to secure heat for the kitchen in such cases, an extension of the original heating system is required, or else a little more fire must be carried; this is particularly true of hot water heating plants.

For the occupant of the house to obtain results from our installation, he must be willing to help the Company in its efforts, by maintaining good fires, removing ashes, clinkers, etc., from around the loop, as some slight extra attention *is* necessary to successful operation.

In making estimates for a kitchen heating system, the Inspector should first carefully inspect the kitchen, taking note of its construction and exposure and govern himself accordingly. A poorly constructed kitchen with loose windows, and doors, will, of course, require more radiation than one well built and due allowance should be made. Each job should be one that will be the means of securing others.

The following rule will be found approximately correct and safe under ordinary conditions.

Having first ascertained the dimensions of the room, find the number of square feet of glass surface in the windows and outside doors, figuring these doors as if glass, and measuring the entire opening of windows and door frames. Ascertain the square feet of exposed wall surface, from which deduct the glass surface as obtained above, and this will be the net amount of wall exposure. Then reduce the wall surface to the equivalent of glass surface by dividing the net amount of wall exposure by ten. This result, added to the glass exposure, gives the glass equivalent of the glass and wall exposure. Multiply this glass equivalent by seventy-five (the cubic feet of air that each square foot of glass will cool per hour), and the product is the cubic feet of air to be heated to overcome the cooling effect of the glass and wall exposure. Now add to this the cubic contents of the room, and we have the total quantity of air to be heated.

It is customary to guarantee a temperature of seventy de-

grees in zero weather. To arrive at the amount of radiation under this guarantee, multiply the quantity of air to be heated by the decimals given below, and the product will give the number of feet required.

In localities where the temperature falls below zero, add to the amount of radiation obtained one per cent. for every degree below zero.

For temperature of water in radiators..... 160°×.0092
" " " " " " ..... 170°×.0081
" " " " " " ..... 180°×.0072

For water we recommend using the multiple .0092; for if water is 175° in flow and 145° in return, the average is 160° in radiation.

The foregoing rule is based upon using direct radiation, and the apportionment provides for one change of air in the room per hour.

For more frequent changes increase the cubic contents by as many times as it is desired to change the air per hour, but the multipliers remain the same.

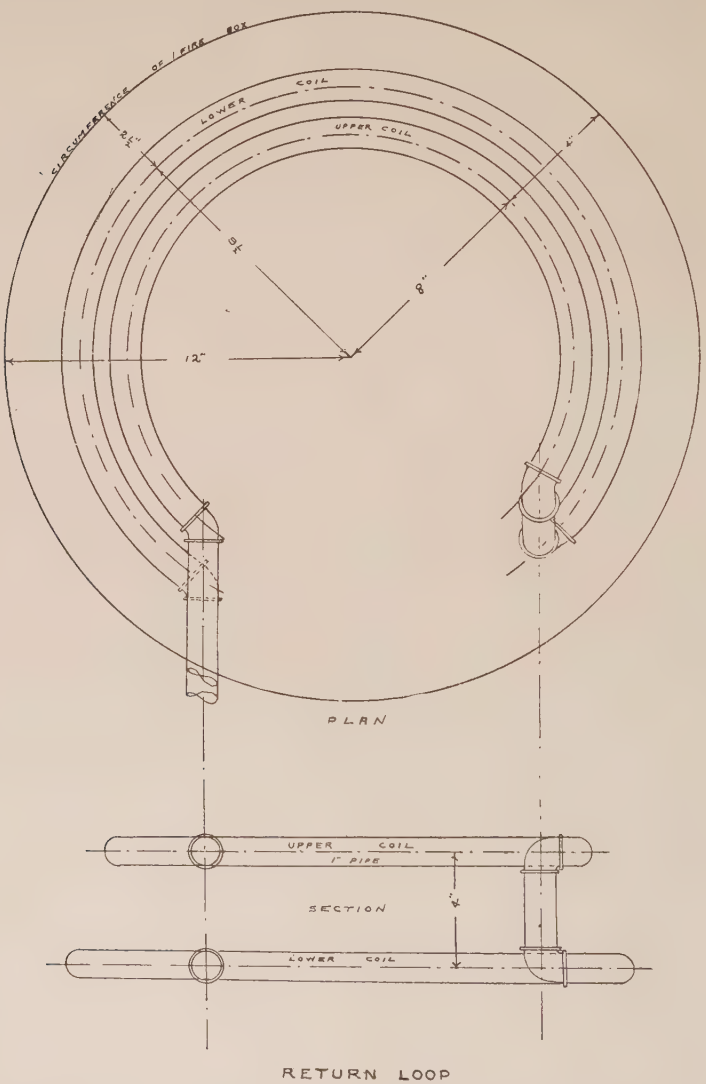
EXAMPLE.

Room—16 ft. wide, 20 ft. long 10 ft. high; 4 windows, 3 ft. wide, 5 ft. high; 2 sides of room exposed to zero weather; 10 in. thickness of wall; 16 x 20 x 10 = 3200 cu. ft. of air in room; 3 x 5 x 4 = 60 sq. ft. of glass in windows; (16 + 20) × 10 = 360 sq. ft. of wall surface exposed including glass; 360 — 60 (glass) = 300 sq. ft. actual amount of exposed wall surface; 300 ÷ 10 = 30 = glass equivalent in wall exposure; (30 + 60) × 75 = 6750 = air in cu. ft. cooled by windows and walls; 3200 + 6750 = 9950 = total in cu. ft. of air to be heated; 9950 × .0081 (multiplier for hot water) = 80.5950 radiation in sq. ft. required to heat room.

The above rule is taken from The Model Heating Co., Phila., Pa.

The Inspector should, by measurements, figure out the

amount of radiation required, length of run, kind and size



RETURN LOOP

of furnace, etc. With this information, we are able to determine the amount and size of pipe to be used in making our

loop or water-back for fire box in the furnace and whether the installation is practical for us to undertake or whether we should refer it to a plumber.

We have found the rule allowing one square foot of pipe in furnace for each thirty-two feet of radiation is not always practical on account of fire conditions; for illustration: take two houses in same row with same kind of furnace and kitchen; the results obtained from same amount of coil will widely differ, due entirely to the operator of the furnace fire.

To secure the best coil or water-back we have tested many water-backs now on the market, also many home-made ones; the efficiency of each varied according to local conditions, amount of radiation, kind of furnace, fire, etc. Our best results have been obtained by a return loop designed by our Mr. Savage. It takes up less room and is not in way of operator of the furnace when cleaning or regulating his fire. When required, we can get in most furnaces, as high as three square feet of heating surface without deadening the fire. This loop is made in our shop of one inch galvanized pipe of proper length, two one inch ells and a short nipple; the bend is on the order of a double hook, the radius of the upper pipe being a trifle less then the lower pipe. The opening of the hook leaving free access to the furnace pot.

Our runs from bottom of kitchen hot water boiler to loop in furnace and return to hot water inlet of boiler, are made in three sizes, three-quarter inch, one, and one and one-quarter inch galvanized pipe, depending on length of run and circulation required. In a few cases, we find it advisable to cover these runs so as to prevent loss by radiation before radiator or boiler are reached, with asbestos or mineral wool covering. If the floor of the kitchen is exposed to the ground, by all means use some kind of covering.

We are using wall radiators having found them, not only to be the most efficient when compared with loop and pipe coil radiators, but easier to handle, neater in appearance, requiring much less space, and they cost much less. They can

be assembled vertically, horizontally or as a plate warmer and are furnished in sizes from four to nine square feet per section, costing about twenty-one and one-half cents per square foot.

PLATE WARMER.

All piping and radiators exposed in kitchen are painted aluminum; this, with floor collars, leaves the work pleasing in appearance, not only to owners, but to their friends. When one installs a modern kitchen, he is bound to show the same,

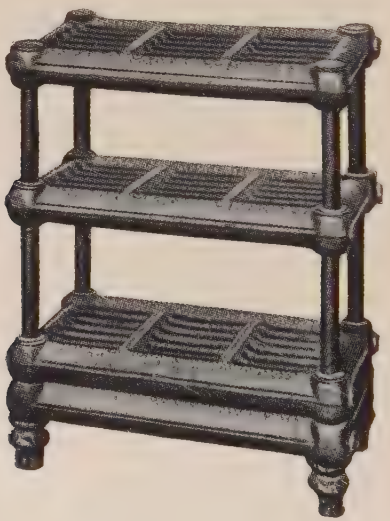


Plate Warmer.

therefore the impression created depends on the general appearance and results obtained.

The coke burner or kitchen heater is being used in a number of cities to further the use of gas ranges in houses that have no furnaces, with good results. We have made several tests of these coke burners, finding the drawback to their sale, to be the first cost. Houses that have no furnaces are those that rent for about twelve dollars per month and the tenants of this class of house cannot pay fifteen dollars to

eighteen dollars for a coke heater. In many cases, a small base burning stove is much easier sold and the results are the same. I have found many occupants of such houses, using a coal heating stove in dining or sitting room, and when door is left open between kitchen and sitting room, they obtain a good working temperature. The majority of such kitchens are small and easily heated.

We want a kitchen heater or coke burner that will be within the reach of all houses. There are many that are now only using their gas range, three or four months in summer because of no economical means of heating kitchen in cool weather. There is no doubt, that such an appliance will have a large sale and would double, yes triple, our present gas sales in these houses. The winter cooking is much more elaborate than in summer, more fuel being required to do the work. Now, why not get this business?

Another problem which confronts us, is the rented house with hot air heating. The kitchens in most of these houses can be heated by extending the hot air flue costing about six dollars, which many tenants will pay themselves. These extensions have proven very satisfactory and are very easily installed. This makes a modern kitchen, all cooking and water heating being done by gas at a saving over the former coal range.

In cities where the sale of gas ranges has been well introduced, it means that many of the future range sales will be renewals which does not mean increased gas sales in every case, therefore, to obtain all-year-round-cooking, we should devote our efforts and range advertising to the abolishment of the coal stove entirely and get an increased use of gas on these renewals as well as on our present investment.

When warmer weather arrives, and furnace is out of use, then to heat water satisfactorily is a problem to many house holders. To maintain a constant supply of hot water at faucets through the house, requires the installation of one of the many satisfactory automatic water heaters. For convenience,

storage or straight automatic water heaters of proper size are giving general satisfaction day and night and at a small cost per gallon of water heated. These are connected either by the direct or reheating system.

I inspected several large building operations in an eastern city that are equipped with direct furnace heat, hot water being supplied by coil in winter, and automatic water heater when furnace is out. When furnace fire is low, valves are opened and the partly heated water from coil is brought to the required temperature by passing through the automatic heater.

When using circulating heaters connected to hot water boiler, we set the burners to pass about the following gas: No. 1 heater thirty-eight feet per hour; No. 2 heater fifty-three feet per hour; each heater being connected with a flue, which helps to increase the efficiency. Our experience has proven that the larger heater will be used more on account of the quicker results. Our aim should be for quick results with the highest efficiency possible.

The cooking range in the modern kitchen of the new houses should be the cabinet type of gas range. A number of these ranges have twenty-two inch auxiliary ovens and six top burners. In a few cases, six foot hotel ranges are being used in houses where there is considerable entertaining. Many of these ranges have been furnished with high shelves, hoods and flue connections. These and the necessary small gas appliances, give you a modern kitchen, but not an elaborate one. There is a demand for a gas range that will compete with the best of coal ranges as to construction for the more elaborate homes that are being built throughout the country.

Modern Kitchen.

Our work this year, (which has been a record breaker in gas appliance sales) has been largely devoted to bringing about the increased use of gas in the kitchen, by conducting

an aggressive advertising and soliciting campaign throughout the year on the modern kitchen.

Another means of advertising is to mail to our present modern kitchen users, a return postal card, worded as follows:—with the average answers given.

"A reply on the attached card to these questions will be

Illuminated Sign.

greatly appreciated, as will a notice of any way in which we can improve your service."

No. 1. How long have you used gas for cooking in both winter and summer?

A. About two years.

No. 2. Do you find it more convenient than the use of a coal stove?

A. Yes, most decidedly.

No. 3. Do you find it more economical?

A. Yes.

No. 4. How many hours per week do you use your gas range?

A. About thirty hours.

No. 5. About what is the difference per month between the cost of gas used in your gas range and coal used in your discarded coal stove?

A. About one to two dollars per month in favor of gas.

No. 6. By what system is your kitchen heated?

A. Furnace coil—some extensions.

No. 7. Do you object to the use of your name in connection with the above questions?

A. Do not.

Out of all postals returned, there was not a single complaint; all being good.

We also sent out another such card to the contractors and architects, and give the average answers to the questions.

To Contractors and Architects

Q. Are your customers, who have rented or bought the houses that you have equipped with all-year-round gas ranges, satisfied with their operation and the cost of same?

A. Yes.

Q. Have these installations given you much trouble for repairs?

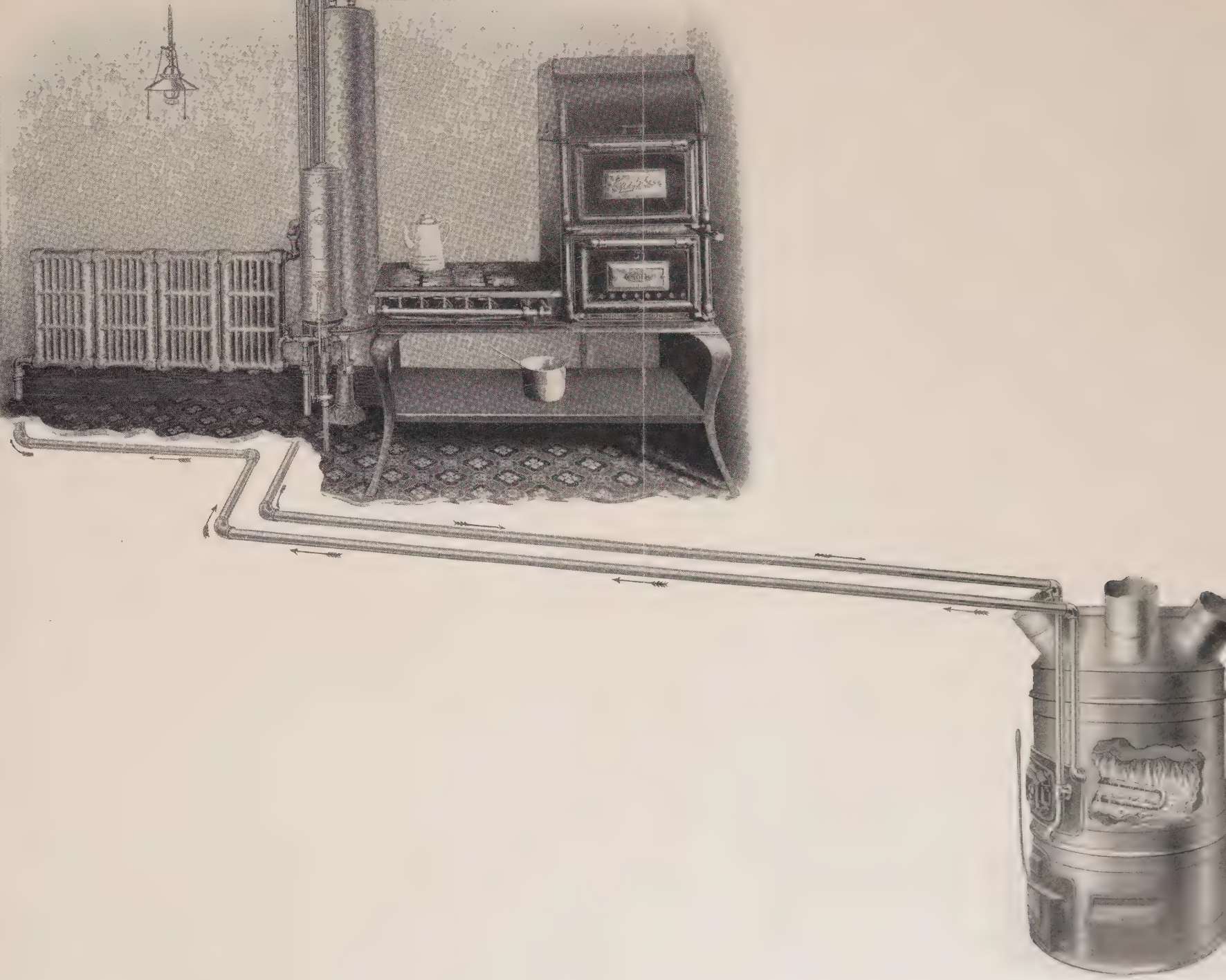
A. No.

Q. What have been the criticisms of this equipment from your customers?

A. Good.

Q. Do you consider this scheme a good one, or advantageous to the builder? If so, along what lines and to what lines and to what extent?

A. Yes, it is the coming kitchen.



MODERN KITCHEN

Q. Does it give you additional selling points?

A. Yes.

Q. Is it entirely practical for domestic purposes after the public has become educated to the value and desirability of its use?

A. Yes.

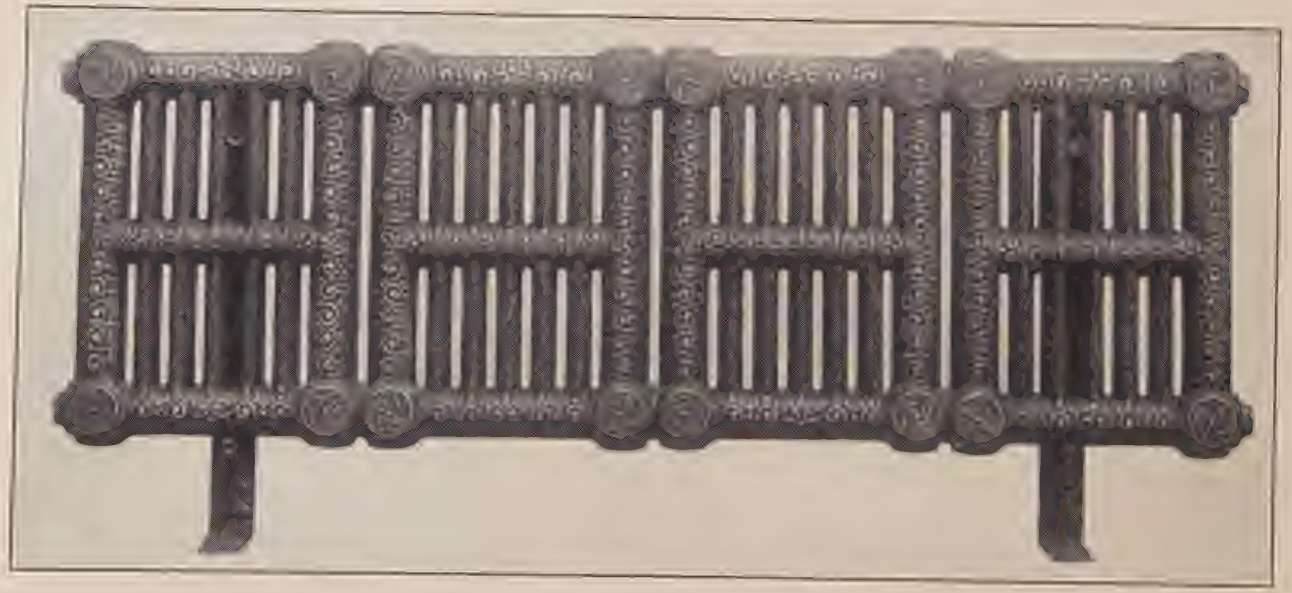
Q. Does it please the men of the house or just the women?

A. Both.

These cards are used for several advertising schemes; at present, they are used in connection with our window display made up with a complete kitchen outfit using a kitchen cabinet, cabinet gas range, water heater and boiler, wall radiator, etc. The postals are tacked on a large board and occupy a prominent place so as to be readable from the street.

The present system of using the gas range for summer cooking only, is so grafted on the most of our consumers, that it will take considerable discussion and educational work to effect a change, but it can be done.

A meeting is held each Saturday morning for the schooling of our business builders, but as these meetings take in all gas appliances, I will only tell of a part devoted to the increased use of gas in the kitchen. The first lesson takes up the principles upon which a new business department is founded and upon what depends its future success. Papers are prepared in advance on the successful operation of gas kitchen appliances, such as gas ranges, water heaters, toasters, gas irons, etc. As only one subject is taken up at a meeting, this gives each man a chance to write on one of the many domestic gas appliances. An imaginary sale of some modern kitchen appliance is often arranged between two solicitors. This has been very helpful in the training of our men, as it enables them to meet all objections offered by a real prospect, and the arguments are very instructive; the men get very enthusiastic in their effort to overcome the other fellow's objection.



Wall Radiator.

We are able to make a small profit by putting our selling price at twenty-two dollars and fifty cents for a furnace connection of twenty-seven square feet of radiation and thirty cents for each additional square foot required, and trying not to undersell but co-operate with the local plumbers. Where sold in connection with a water heater, the price is thirty-five dollars or two dollars and fifty cents less then when sold separately. For installing coil, less radiation, we charge fifteen doliars.

Two hundred modern kitchens picked out at random, show an average of fifty-two thousand cubic feet of gas per year, showing that if every house had a modern kitchen our annual sales would be almost double what they now are.

The pushing of the modern kitchen could be helped by the Gas Companies combining for the purpose of advertising in several national home papers, such as the *Delineator, Ladies Home Journal* and a good magazine.

All of this additional business is on *present mains and services.*

THE CHAIRMAN: Gentlemen: You have listened to a very interesting paper. It is evident that a small meeting of men intensely interested in a subject will be better able to do justice to it than a larger meeting where there is not so much interest. I assume that you are all interested in this subject as it promises an immense increase in the output with very little added expense. I am now going to leave the subject open for discussion.

MR. CLABAUGH: Mr. Chairman: To me this is one of the most interesting papers I have listened to for a long time, because for the last nineteen years I have been talking about furnace connections. In Omaha we put in the first one I had ever heard of. We started in using a three-quarter inch pipe, making a return in the furnace. In the beginning this was very satisfactory, but after using it for some time we found the pipe would soon fill up with Missouri River water sediment. We then took a three-inch nipple, and in that nipple

ran a small pipe down to within two inches of the bottom; the nipple was about nine inches long, in the top of that was a three-quarter inch hot water return. This was placed down in the furnace, and it was very satisfactory as far as we had gone, but it had the objection of being too large for a small furnace, and of throwing the fire to one side. We also used the Acorn heater. This was supposed to be made with a very thin bottom, but they thought to improve upon it by adding what was called a clean-out, by putting a nut on the bottom, which was utterly impossible to take off after it had become heated a long time. We were not satisfied with this heater because all the sediment gathered at the bottom and remained there. We finally adopted a one and a quarter inch return and I think if Mr. Thomson will run that size return he will get very much better results and the pipe he will find, will need much less cleaning. In Omaha almost every house has a furnace connection: We make very few of them ourselves to-day. There is not a house built, or a furnace put up that has not specifications calling for furnace connection with the kitchen. A great many of the boilers are put down in the basement, near the furnace, and they have an auxiliary heater for the kitchen connected with the hot air furnace or with the steam system. The architects understand this perfectly, and there are no houses built now without the furnace connection. Our gas stoves are not taken out in the winter time; with very few exceptions they burn all the year owing entirely to this winter coil in the furnace. Mr. Thomson has suggested the coke heater in the kitchen. I would suggest for the coke heater the putting of a little coil around the side, we have tried that in a number of cases, it has given hot water easily, and will keep the coal range out of use. I know of one locality in which there were six three-family houses built, and in which there was only one coal range, and that has been taken to the basement. We feel there has been nothing in our business that has increased our out-put more than this furnace connection. It appeals to every one, because they

can have hot water, and they can keep the gas range in use. When this was first done people would come to me, and say: "We do not understand this; we do not believe the Gas Company wants to give anything away, and there must be some ulterior motive behind the proposition. We have a gas hot water heater and it is perfectly satisfactory; why do you want to cut it out?" I told them there was no ulterior motive whatever, except for their good and for our good. We knew positively that with the extreme cold weather we have in Omaha the gas range would have been taken out and the coal range supplant it, if it had not been for our proposition, and, therefore, we were willing to lose the sale of that amount of gas in order to keep out the coal range on the principle that we would rather have a half loaf than none at all. It appeals to people. I think the average cost of the equipment was $6.90. We do not cover our pipes. I think it is a good idea to cover the pipes, but as a rule you will find that where there is a furnace in the cellar it is practically the hottest place in the house unless the furnace is covered with asbestos. I know of nothing that will increase the output more than this furnace connection; and I feel particularly glad that the gas men of the country are looking into this subject. I have talked it for the last fifteen years, and I cannot say too much in its favor.

Mr. Pettes: I have one of these furnace connections in my house in East Orange, and if I could not get another one I would not take a thousand dollars for it. There is nothing that has given better satisfaction. We get hot water and plenty of it. We have no radiator in the kitchen. The kitchen, which is of modern size and modernly equipped gets all necessary heat from the hot water boiler. In summer we use a Ruud heater. During the whole year there is not a pound of coal used in my house for cooking. I would like to ask Mr. Clabaugh if the heaters in Omaha are principally hot air or steam. We found a great deal of difficulty in our

territory in getting our connections into some of the steam heaters.

Mr. Clabaugh: In answer to Mr. Pettes I will say that the majority of the heaters with us are hot air heaters. There are a number of steam heaters, some of which we have been unable to put the coil in. I suggest putting the coil in the flue pipe where there is certainly a great deal of heat passing up the chimney at all times that would keep the water hot. I think a connection could be made there which would be very satisfactory.

Mr. James Hanlon: I wish to compliment Mr. Thomson on the excellence of his paper. Our company has made an aggressive campaign for this class of business for the past five or six years. As a result we have reaped a harvest and we are getting it more and more every day. We are going a little further now in the city houses and surburban houses as well, and we are getting the builders to place radiators in the kitchen and this past season has been one of our best seasons so far. We have done the largest business, just through this modern idea of getting people interested in using gas for cooking all the year round, instead of as formerly for only two or three months. You would be surprised to see how the idea has taken among our consumers. A large number of houses that were considered impossible to reach a few years age are putting in gas ranges now. They are not leaving out the coal range, but wherever house is steam heated, we manage to get in an installation of a gas range and gas water heater; and if the house is large enough we install generally an automatic water heater as well, leaving out the boiler entirely. We are preparing now a book which we propose to issue to architects and builders, and also to mail to every prospective builder or owner of a home, that we think will help this work along. We have made arrangements with a company that operates in New Jersey called the Dodge Reporting Company that furnishes us with reports, and by that method we get advance information from the architects when-

ever a house is contemplated, long before the building permit is issued and before the record is placed with the city or town authorities. We have men especially detailed for this class of work, and the results have far exceeded our expectations.

Mr. C. W. Hare: It is safe to say that 60 per cent. of our consumers would prefer, without any solicitation, to use gas for cooking throughout the year, the only question in their minds having been how they should heat the kitchen in the winter time. Consider this a moment. A large majority of your consumers want to use, roughly, twice as much of your product for fuel as you are now supplying them. We all say we want them to use it, but are we all doing anything definite to secure the result? Several methods have been tried and those mentioned by Mr. Thomson in his very able paper have proven successful.

If we want the public to adopt these methods we must advertise them. We all talk about them in our offices and we agree that it is a good proposition for us to have our consumers use gas for fuel in winter time but that won't get the public to use it.

You cannot expect a solicitor to go out and instantly convince the entire public that we have what it wants. This is one instance where newspaper advertising and circularizing will produce good results in paving the way for your solicitor.

The coke heater referred to by Mr. Thomson in his able paper answers the requirements in some instances. Show it on your sales floor; advertise it; impress upon the solicitor the necessity of talking about it.

The coil in the furnace, connected to the kitchen boiler for the supply of hot water, the kitchen being heated by a radiator on this connection or by a hot air flue or steam radiator connection from the furnace or steam boiler, is really the ideal installation.

Get in touch with the architects and builders in your territory and let them know the advantages of it.

Arrange your prices so that they make the arrangement an attractive proposition.

The first cost is what the builder, with houses to sell, looks at, to a very large extent. When you have educated the public to expect a modern kitchen it will not be necessary for you to figure so close.

Try to get the coils installed in old houses. To make a success of this I believe the gas company should undertake the work of installation.

The main point is to let the public know that they can use gas for fuel throughout the year and have a comfortable kitchen in the winter time, and hot water.

The results you want will follow.

MR. ROGERS: I think we have to contend with the same conditions that Mr. Thomson speaks of: We have a manufacturing city, (Paterson) and what concerns us most is how to increase the consumption among the wage earners. In our town the better class of houses are universally steam heated. We have a great many two-family houses in which each of the two apartments have a separate steam heating plant; and, of course in those houses gas is used for cooking all the year round. We have had some houses built without a chimney to the kitchen. I know I had to hustle to get a man to put the service in a house of that kind because the people couldn't get anything to eat until they got their gas connected. But the majority of our population is employed in the silk and other textile mills. Some of them make good wages above the average, and are good people, but they usually live three families in each house, that is, one family on each floor of the three stories. I have tried to get such people who use coal ranges to use these newer methods and we have tried to figure some means of making a smaller boiler with a gas water heater but the expense has always been too great. I would like to ask Mr. Thomson, if he has any suggestions as to how we could encourage these people to throw away their coal ranges altogether and use gas all the year round.

THE CHAIR: Mr. Thomson will close the discussion and answer all those questions at once. Any further discussion?

MR. EAVENSON: I would like to know the material used in the coil and I would like to ask the gentleman who uses the inch and a quarter coil, whether he has been successful; we have used them with very excellent results. I would like to ask if the coil is bent to take the curve of the fire pot or does it extend through the fire pot? I would like also to ask about the shape of the coil and the material.

MR. THOMSON: In reply to Mr. Rogers' question about small houses, we have taken care of some by putting in a small coal heating stove. Others we have let go until we can get a satisfactory coke heater. Houses that have no furnace are generally occupied by tenants that cannot afford big prices for appliances and for that reason we have been devoting most of our efforts to larger houses costing from $3,000 up. In regard to the material of the pipe, we are using wrought iron pipe; I would not say that it is not steel, but it is supposed to be wrought iron. We are making tests with brass and copper. I am afraid we will have to return to the wrought iron pipe. We have installed over 400 furnace connections in a year and a half. The newer and suburban houses are being taken care of by the builders. We have our shop busy now with the old houses.

MR. SEARLE: In order to make this furnace connection popular and cheapen its use it seems necessary to have skilled men to follow it up and keep it working. Rochester has put 3,000 in use in the past two years. As to the price, we started first with $5, and then up to $12.50, and up to $20. We have eight plumbers doing this work, and send an expert to supervise each installation. We have found as Mr. Thomson remarked, that almost every installation is a distinct case of its own. We have tried the brass and copper connections, and these have overcome the more common difficulties.

In Rochester we have seven and a half months of heating, that means that the gas range has very little use in one

month, a little bit more during two months, and for three months is used practically at its capacity. This furnace connection brings that gas range to its maximum use every day in the year. Cooking in winter means heating very cold water; that means a lot of gas; it means boiling vegetables that are almost frozen that means a lot of gas, and looking at it comparatively—it means 18,000 feet in Rochester when a stove is used for the five summer months, and 40,000 feet when used all the year with a furnace connection. So you can well afford to put your furnace connection in. I am now referring to gas consumption of a range only. It gives yon something like 122 per cent. increase.

Mr. Prichard: I would like to emphasize the point that has been made in regard to the stopping up of the wrought iron pipe. I have tried putting the wrought iron bend in the furnace, and found at the end of two years that it was absolutely stopped up, and I think if it had not been attended to there might have been serious results. Since that time we have always recommended a brass coil, the pipe can be put in through the furnace door, and made inexpensive. We have had good results in putting in these little hanging devices that hang over the fire pot in the center of the furnace, and use a radiator in the kitchen, which gives the kitchen all the heat necessary. The people in the house forget they ever had a coal stove. In other houses where we have been unable to do this we put in a gas stove with coke heating side attachment, and we have found those extremely successful, because they start quickly, and if they die out they can be lighted easily, and many of those have the coil in also. Then as an auxiliary to that we have always advocated putting in a small six or eight dollar heater connected to the top of the kitchen boiler and the combination of the three or any two out of the three, has so far hit any case we have come upon. We have many cases such as the gentleman refers to of people who are not very large wage earners, and many of them are families of one, two or three persons, who all work in the

shops and go to work at an early hour, and we find it is an easy matter to get these people to use gas in the kitchen, because they like to sleep in the morning until the last possible moment and if they have a gas stove with a hot water attachment they can get their hot water ready as quick as they can get their clothes on and soon have their breakfast.

MR. PETTES: I would like to ask Mr. Clabaugh in regard to the coil in the flue pipe. I have tried the loop around the furnace, I have tried the loop across the furnace, and I have also tried the Acorn. I like the loop across the fire the best. And as far as stopping up is concerned, I looked after that in my own house. This was done as an experiment, as an argument either in favor of it or against it, and I had an Acorn in service for two years; I took it off, sawed it in two, and I found there was no deposit in it at all, when I fully expected there would be.

THE CHAIR: Your town has good water?

MR. PETTES: Yet, it has good water.

MR. CLABAUGH: In answer to Mr. Pettes' question, you will remember this coil in flue pipe was suggested to me yesterday; I have never tried it, but it seems to me that it might be used where we could not get into the furnace pot. Now, as we use the furnace connections the pipe goes in the side of the door and goes straight across the furnace with an elbow. We have very little trouble with stoppages, although we do have some. The furnace connection will run all right for four years, at the end of that time it will probably take twenty minutes to clean out the hot water pipe where it enters the boiler, that is the place it generally stops up. I do not believe it will be necessary to use brass coils even in Omaha. I think the additional cost will be very much against it. We connect the circulating water heater for ten dollars and make a profit on it. We are doing very little of that work ourselves now. It appears now in the specifications of every plumber in town, in fact almost every furnace that is sold must have an opening in that furnace for the coil. So we have got the people

interested; it is a thing that has been advertised so extensively for the last eighteen years that everybody knows what it is.

THE CHAIRMAN: I do not hear any conflict of opinion as to the merits of this thing. I would like to hear some discussion as to which is the best: the coil in the furnace or the other?

MR. PETTES: In our judgment the coil in the furnace is the best proposition. We want heat in the kitchen, and we also want a supply of hot water, not only in winter, but in the summer time. By means of this furnace connection we can give them hot water with very little additional cost in the winter time. In most instances, in Jersey City, where I am familiar with this proposition, it is not necessary to put a radiator in the kitchen. The heat from the boiler in the kitchen is enough. I have in mind one instance that might be of interest. We put an Acorn plug in a furnace in Jersey City, and we heated two boilers and two radiators from that furnace. That was three years ago, and it was a very cold winter. I went around there during that winter several times, and the party was thoroughly satisfied. Every room was cozy which that heater furnished, and they were getting plenty of hot water both from the down-stairs boiler and the up-stairs boiler. We have no trouble whatever with stoppages in the heater. We also use galvanized iron pipe, one and a quarter inch and one and a half inch, the one and a quarter I believe is right. We have had no trouble with it. We use the clean out cock, but we use it for another purpose, and that is to have a little hose pipe connected with it so that we can fill the hot water reservoir in the furnace, and also to put water in the fire pit to wet down the ashes so as to have no dust in the house. We do not use the safety valve. I do not see why that should be necessary at all. We do not usually use radiators; we did use a few in the early days, but we did not find them altogether satisfactory. We have found that the radiation from the boiler in connection with the heat from the gas stove will heat the kitchen sufficiently, and where it will

not a register is put in the kitchen from the furnace at very little cost, about six dollars. I would like to ask Mr. Clabaugh whether he has had any cases where he has put these connections in these houses with several families where they have separate heaters, and where the landlord does not furnish hot water or heat? That is a very prevalent condition with us. We have any number of ordinary flat houses with us, with from four to twelve tenants, and they all have separate heaters, and, of course these people do not feel like paying ten dollars to get a furnace connection in a rented house. They may move, probably do move once a year. I would like to know if he has any conditions of that kind, and I would like also to know how he manages to get that connection made for $6.90, as he mentioned. I have heard of that price for several years, but I never could figure it out.

Mr. Clabaugh: Answering the last question first, I will send Mr. Pettes the figures when I get back. We do not have the conditions Mr. Pettes speaks of. Where we have six or eight or ten families in a place, the heat and water is furnished by the landlord.

Mr. Thomson: In regard to the small furnace in the small house, I will say I think we have tried to use too large a pipe in such furnaces. We are now using a smaller pipe. When I said we used a three-quarter inch pipe or a one and a quarter inch I meant that it depended upon conditions. Sometimes we go down to within seven inches of the grate, and do not go across the top. We have found that trouble particularly with the hot water heating systems. We have had at times to change the coil so as to get it in the center of the heat zone. We are figuring now on using gas heated radiators in the kitchen, so that you can light this hot water radiator—it is a radiator that you are all familiar with; you can use it in connection with hot water or steam heating; of course we will use that radiator in the kitchen, and turn our loop so you can light the gas under the radiator and it answers the same purpose as the furnace coil.

THE CHAIRMAN: I would like to ask any gentleman who can answer it whether or not the kitchen boiler itself is not sufficient, if kept full of water, to heat an ordinary kitchen?

MR. PETTES: In my house the kitchen is the most comfortable room in the house. I like a warm house, so does my family, and we run the fire pretty strong. You have to with a hot air furnace, I think, and the boiler is always hot. I have seen installations where they had to draw the water off, it made so much steam in the boiler. It may be of interest to some of the gentlemen here to know that in our district the agent has been able to get a Ruud heater in some of the two-family houses and the landlord pays the bill, so that the hot water will cost the tenant nothing, but you have to get that kind of installation in a rather high grade of apartment house. The gas bills I believe run about six or seven dollars a month, which is not much of a drain on a landlord when he is getting from $35 to $40 a month for each apartment.

THE CHAIRMAN: If there are no further remarks I will ask Mr. Thomson to close the discussion.

MR. THOMSON: I do not think I can add anything. I would like to ask Mr. Eavenson—while we are considering making a change from brass to wrought iron and steel,—how he tells the difference between them. I think he has made tests on wrought iron and steel.

MR. EAVENSON: When I asked the question as to what material was used I did not have in mind brass coil; I had in mind only the so-called wrought iron pipe. Now, your invoices will probably read "wrought iron" pipe, but in most cases I think you will find it steel. When you come to use that steel pipe in the fire you are going to get in trouble with scale. In other words the scaling will be greater with steel pipe than with wrought iron.

A rising vote of thanks was then tendered Mr. Thomson for his very able and interesting paper.

THE CHAIRMAN: The next paper is by Mr. Karl A. Schick of Rochester, "The Solicitor." Mr. Schick is not as yet a member of the association, but has prepared this paper at the request of Mr. Searle.

THE SOLICITOR.

It has been said that the solicitor is born, not made; it is also contended that such a notion is erroneous, and the adherents of this latter contention have gone to the length of evolving a more or less exact science which essays to make a successful salesman or solicitor of anybody desiring to make more money than it is possible to make in any of the professions, etc. With these makers of salesmanship science I have no desire to quarrel. I mention their operations because to the man in charge of a Gas Company Commercial Department, the solicitor question is ever a live and pressing one and I had hoped that a helpful light was to be shed on the subject as a result of the science. After carefully reading some of the text books I was compelled to the conclusion that the science was nothing more than a sort of treatise on the possibilities of development of man's natural talents. There was presented nothing really new, and although the various books were replete with intimations of revelations to come in the all important "sale closing" line, it developed that the salesman was left to his own resources at the critical moment of sale consummation.

Thus the evolving of successful solicitors is still a matter between the men available and the head of the Sales Department. We have to depend largely upon our intuition in selecting the men, and upon our experience for their preliminary education—what the result may be only time can tell. If the men we select have the necessary latent natural talent, their work in the field will tend to develop such talent and successful solicitors will be the result, if not, then it is my humble opinion they are in their wrong element and will, therefore, never become successful in that particular sphere.

In the last analysis the solicitor must be judged by the

appliance sales he consummates which are at once revenue and friend producers for his Company. His operations are more or less valuable as his sales reduce the gaps or increase the peaks, while the greater the number of his sales the more nearly does a Company draw to the maximum of operating economy, which a close approach to capacity produces.

Rules for Solicitors: In dealing with the solicitor one of the most serious mistakes is loading him down with a book of rules many, in fact most of which, are extremely unimportant, and which serve only to rob the really important ones of their significance.

The rule question has been handled by our Company in this way; the first page of the solicitors' hand book runs thus:

To Representatives

"The essentials for successful salesmen in the gas and electric appliance business are:

Neat personal appearance;
Familiarity with the conditions in your District;
A working knowledge of what you are offering for sale;
An accommodating spirit;
Truthful statements;
Control of temper;
The exercise of extreme care in the matter of promises;
Gentlemanly persistence and patience, and entire absence of familiarity either in manner or speech.

All of the foregoing, none of which are either burdensome or unreasonable, are required by the Company of its representatives and will be rigidly insisted upon.

Every morning at 8.15 sharp a meeting of representatives will be held in a room provided for the purpose and all will be expected to be on hand promptly and to observe proper decorum.

Ask whatever questions that are necessary for a proper performance of your work, avoiding questions on matters foreign

to the purpose of the meeting, thereby avoiding unnecessary delay.

Results, plus observance of the essentials, will be the standard by which your value will be judged.

Do not be afraid to talk a particular installation because of its cost; be familiar with the advantages of the appliance you would install, have faith in its desirability, and you will be able to convince others."

You will note we have substituted the word *"Essentials"* for the word "Rules," but have so worded a particular paragraph as to make it clear that the essentials will be insisted upon. The elimination of the word "Rules" is in line with our general policy of avoiding harsh sounding words in our operations wherever possible.

ASSIGNMENT: It has been our experience that, in order to foster and develop a real liking for his work on the part of the solicitor it is necessary to impress upon him the fact that he is not a mere canvasser, as that term is commonly applied. In order to make this quite apparent we give each solicitor a certain district for which he is held responsible, except in the matter of industrial appliances and main extensions, which fields are covered by specialists in those lines. All calls within his territory are given the solicitor, records are kept thereof and reports required in every instance. A solicitor is not permitted to attempt to secure business in any other territory than that alloted him. This plan lends a sort of dignity to the work wholly lacking if men are permitted to get business promiscuously and has, so far as our experience goes, produced excellent results.

REMUNERATION: After having tried straight commission, straight salary, and salary and commission, the conclusion reached was that straight commission produced the best all-around results, therefore, except in the case of *special* men, we pay solicitors a straight commission of 15% on selling price of appliances and 25c. each for meter and service orders. Commissions are due and payable only after appli-

ance is installed and payment made thereon. In order, however, that the men may not suffer while work is in progress we allow each man a certain sum each week, based on his earning capacity, and these weekly amounts are deducted whenever commission checks are issued.

Believing that liberal remuneration pays the Company, we allow the solicitor a commission on office sales whenever such sales can be traced directly to solicitor's efforts. The office sales record is open to solicitor and investigation is made of any sale at solicitor's request, the prime qualification necessary being that investigation must show solicitor "talked" the particular appliance sold. In order to discourage any tendency to abuse this advantage the solicitor is instructed to the effect that the investigation privilege will be denied him if the number of his orders "not approved" indicates any unfairness on his part.

Discipline: Except in cases of absolute dishonesty, our policy is to point out the gravity of the particular offense, advise offender and warn him against repetition on pain of dismissal. Flagrant dishonesty means dismissal upon convincing proof. In every instance the solicitor's side of the case is heard and weighed carefully and he is made to feel at all times that he will receive a square deal. At this point it might not be amiss to remark that our judgments on the short comings of the solicitor should be tempered by our knowledge of the obstacles he must meet and overcome, if we are to have the volume of business to which we feel we are entitled and which we expect him to obtain.

Encouragement: No work or act redounding to the solicitor's credit is too small to merit an expression of praise, and it is given him in open meeting. This serves to stimulate ambition and is productive of good results.

We further allow points on appliance sales, a faithful record thereof being kept and posted weekly on blackboard in meeting room. A trip to the N. C. G. Association Convention is the

prize awarded to the solicitor having the greatest number of points to his credit at the end of a given period.

Prospects: Believing that prospects can best be acquired by canvassing, each solicitor is required to make daily canvass, submitting report on regular form as to appliances found installed and prospects located. He is further required to have canvass of district completed in a given period, the length of time varying with the conditions in each district.

Meetings: Are held every morning at 8.15. Solicitors are encouraged to submit questions upon matters relating to their operations, and these are answered in the most painstaking manner possible. Whenever an installation of appliances of out-of-the-ordinary character is made it is explained in detail at the morning meeting and the solicitors are invited to inspect such installation in order to thoroughly familiarize themselves therewith.

Papers from among those appearing from time to time in the various gas periodicals are read, usually in installments, and discussion invited and encouraged.

Other Aids: We conduct an advertising campaign in the five local newspapers daily throughout the year. Solicitors are encouraged to criticise the various ads. and offer suggestions for their betterment. This plan we find serves to stimulate interest on the part of the solicitor and helps convince him that the Company is not unmindful of the important part he plays in the organization.

We also furnish solicitors with handbooks, catalogues and booklets, which are prepared with great care and printed on excellent paper. Handbooks, catalogues and booklets such as those submitted are costly, as such things go, but we have known concerns to be unfavorably considered because of the trashy character of their printed matter, and we have no desire to invite a like fate either for our solicitors or ourselves.

Every appliance the solicitor offers for sale is on display

in our show-room, and connected with gas supply so they may be shown in actual operation.

Service and other complaints reported by solicitors are reported back to them after having received attention. This we do so the solicitor may again call on the customer and at a time when the prompt attention given his complaint has paved the way for further appliance sales.

Solicitors' Estimates: In this regard we have adopted a plan which, so far as we know, is entirely new. At the beginning of the year each solicitor is invited to submit estimates of the number of sales he expects to close on various appliances during the year. These estimates are written in red chalk against his name and under the various appliances on a blackboard specially ruled for the purpose. At the beginning of each week his total sales to date are credited in white chalk against his estimates, showing at a glance his progress toward fulfillment. The Convention trip credit points are also totalled each week and credited on the board so that the work of each man is an open book to his fellow-workers. We have found this board a splendid medium for exciting a healthy ambition to excel. It is also a constant rebuke, silent but extremely effective, to the solicitor who makes the mistake of allowing his efforts to relax.

The foregoing presents the "kernel" of our method of handling solicitors and we ascribe to it in a large measure the success of our Commercial Department. I am not unmindful, however, that geographical lines quite frequently delimit the field wherein a particular policy may be pursued with uniform success, as witness the difference in characteristics between the people of the East, West and South, therefore, I leave to you, gentlemen, the question whether the policy we pursue is in whole, or part, available.

In closing I desire to say it has not been my purpose to attempt to lay down any hard and fast rules for the guidance of anybody in the matter of dealing with the solicitor. I have only attempted to tell in a general way how we handle solicitors

in Rochester, in the hope that what I have offered may in some degree be of benefit to some of my auditors and in the further hope that a discussion may ensue that will prove beneficial to us all.

THE CHAIRMAN: Gentlemen, the paper is before you for discussion.

MR. C. W. HARE: I have listened to Mr. Schick's very able paper with great interest. Mr. Schick states "in the last analysis the solicitor must be judged by the appliance sales he consummates." It is for his results in sales that we pay him. We demand that he be accommodating and truthful to our customers. We demand that of all our employees. I firmly believe that General Solicitors, and by that I mean particularly men who sell domestic appliances, must first of all be salesmen. If they are so, with the expenditure of a little time and patience we can teach them the points that they should know regarding the appliances they sell.

Some may say, for I have heard it said before, that they have taken fitters from the shop and taught them to be salesmen. You probably did not teach them, they were salesmen anyway by nature and your good judgment lay in allowing them to prove it.

I am particularly interested in what Mr. Schick has to say regarding his method for remunerating his men. He recommends a 15 per cent. commission on all appliances sold. He also carries on the Credit Point System of compiling their sales. The company with which I am connected makes a general practice of paying straight salaries. In addition we have the Credit Point System, each appliance being given a definite rating in points, according to its value as a gas consumer, or its estimated effect upon gas sales. Meter and service applications, reconnections, etc., are all given ratings in credit points. The solicitors are daily advised of their standing on this basis as well as that of their co-workers. When a man has

continuously shown that he can earn a higher rating in credits, we raise his salary.

The particular point we like about the credit points is that it reduces all sales to one basis, making easy comparison. While our sales on this basis have been very good, we are considering if we could not do better if we eliminated the straight salary and established a definite value to the solicitors of about 15 cents for each point earned, paying the solicitor monthly the total value of his points on this 15 cent basis. In connection with this we would guarantee him a definite salary, the amount to be a few dollars below his average earning capacity in points. This guarantee would be deducted from his total earnings in credits. If his earnings fall below his guarantee he will be paid the guarantee but we will bring it sharply to his attention and if such a condition continues to exist we will reduce the guarantee. This method we believe will prove superior to the method outlined by Mr. Schick, wherein he pays a commission on the selling prices of the appliances but keeps a comparative record of the solicitors sales on the point basis.

I believe the amount of any commission should be based on the thing which you are asking the salesman to produce. If it is credit points, base his salary on that; if it is dollars and cents value base it on that. I would have no objection to paying a commission on selling prices, as generally speaking selling prices are a pretty fair indication of the gas consumption of an appliance, were it not for the fact that certain matters which we want solicitors to attend to, such as meter applications, service applications, burner maintenance contracts, etc., have no selling price and it would therefore be necessary to place some working value on them to make the commission equitable.

There are so many excellent points brought out by Mr. Schick that I trust that every man connected with the sales department of the Gas Companies will read it carefully.

Mr. Searle: It may seem a little out of the way in a dignified meeting like this to show a cartoon. But in my travels

throughout the country I have found that in small companies the superintendent is also the solicitor, and sometimes the president is narrow-minded, and can not be made to see what the superintendent wants him to see. Our Mr. Schick got up this cartoon to make clear to the president what a solicitor was, and what he had to overcome, what he had to go up against in order to bring money into the coffers of the company, and also to impress upon his mind that he was asking for the privilege of making money for him. I know there are some here who, if they could get that cartoon before their president in such a manner as to show how he is really deceiving himself, it will do more good than the reading of Mr. Schick's paper. A broad gauge spirit will inspire confidence and honesty in men. I would not stay in the lighting business forty-eight hours if I did not make money. I could not afford to. The same thing holds good with the solicitor. He is in the game for all he gets, and the more he gets the more he works. We have tried commissions, and we have tried straight salary. When we were paying straight salary the sales fell off 100%. Going back to the commissions plan there was an increase of 100 per cent. again. On commissions the men are working noon times, Sundays and nights, always on the job, because there is something in it. I have had a man approach me on the street car and ask me all about a gas range and want me to take the order. I took his order all right, but I asked him to go to the canvasser, because the canvasser got a commission out of it, and it made a better and more friendly feeling toward the company, to know that the company was allowing a commission to the men. They say: The company takes good care of its employees. They speak of it to others, and it makes friends, and a friend means a good customer.

Mr. Hanlon: We have about 150 solicitors, ninety-eight of those are lighting men, whose special work is to look after the lighting of stores. We have also men who devote their time to the power business. I have sometimes said

there was a death rate in the gas business; houses are torn down, people die, and the solicitor meets all this, and becomes a very important man. I think we all can learn something from this discussion.

MR. GEARING: I would like to ask Mr. Schick in regard to the pricing of the merchandise; if he figures it to come out even, or is he losing on the merchandise sales, or is he making any profit, in figuring his 15 per cent. commission and his cost of connections with the price added to his cost of appliances?

MR. SCHICK: I think Mr. Searle can answer that better than I can.

MR. SEARLE: After this paper was prepared it was discovered that Mr. Schick was not a member of the Institute. He has recently come into the position of superintendent of a commercial department, and it was my own fault that his application for membership was not sent in in time. Our thanks are due Mr. McDonald for allowing him to present his paper, and therefore I am going to take the liberty, as a member, of answering the questions that may be put to him, with his help of course.

THE CHAIRMAN: I will say that the Board of Directors passed a resolution that all applicants for membership should be invited to attend this meeting.

MR. SEARLE: I will answer the question asked of Mr. Schick. We have established at Rochester a policy that has been so beneficial that we now feel that the plumbers and iron mongers are all in one family. We have steadily raised our prices on appliances to a point where they all can do business at a profit. For instance, we are selling a 16-inch range for $17. The price will go to $18 in November. We are selling the cabinets at list; that will more than let you out with a profit. We have now a happy family of 89 plumbers and about 12 iron mongers that are actually building up our business, because they are building up their own, and that has all been done by co-operative education. Those

prices will tell you whether with a 15 per cent. commission there is anything in it or not.

MR. EAVENSON: I would like to ask Mr. Searle what the average price paid these solicitors is, on the present basis?

MR. SEARLE: I will ask Mr. Schick to take the floor to answer that.

MR. SCHICK: The solicitors are paid on the commission basis what they are able to earn. Their average earnings run from a thousand to fifteen hundred dollars a year. There are some who earn more than that.

MR. PETTES: I would like to ask Mr. Schick what objection he finds to the guarantee plan. It always struck me that a man would feel a little safer if he knew he was going to get a certain amount for sure, say at least twelve dollars a week. That would probably pay his living expenses. I would like to know what trouble he found with the combined salary and commission plan.

THE CHAIRMAN: Mr. Searle says when they followed the salary plan entirely the receipts fell off.

MR. MCSWEENEY: I have not the honor of being as yet a member of this institute, but I would like to say the paper called attention to the fact that at Rochester we allow a man a certain weekly stipend based upon his earning capacity. He cannot suffer while his work is in progress, the amount of the commission depends upon the man, and the weekly stipend is deducted from his commission checks when they are issued. During the winter months when the business falls off, as it does very materially, this weekly stipend goes on just the same.

MR. SEARLE: Without commissions our business went to pieces. We tried it out for a year, but we found that the non-commission method as a business-getter is a failure.

THE CHAIRMAN: We have another paper before us, and unless Mr. Schick wishes to say something, we will pass on to the other paper.

MR. PETTES: I move that a vote of thanks be extended to Mr. Schick for his very valuable paper.

The motion was seconded and unanimously adopted by a rising vote.

THE CHAIRMAN: The next paper is by Mr. Charles M. Cohn, of Baltimore. As he is not present Mr. Scott will read it to you.

COMMERCIALISM.

BY CHARLES M. COHN.

I shall briefly discuss commercialism. The shortness of the time of the Convention, and the consequent practice of abstracting papers, suggests the advisability of merely presenting a few ideas on the subject for discussion and amplification by the members of the Institute.

It may be truly said that commercialism, in the broad sense of the term, extends to all the activities of the gas industry. It is the dominant influence, the controlling force, in the organization and growth of the business, and includes within its scope many of the problems of production, distribution and use of gas.

The business of supplying a community with gas, either manufactured or natural, is essentially a commercial enterprise. In considering commercialism, it is well to bear in mind that the object and purpose of the existence of a gas company is distinctly commercial. Its charter and franchises are merely the corporate rights to engage in, and the authority to carry on the business of supplying gas.

The organization of a gas company is usually considered from the standpoint of two broad divisions—the engineering and the commercial. The technical work of designing and installing the necessary equipment for gas making, providing adequate storage for the gas at the plant, and the construction of the distribution system, are purely engineering features. While there have been a great many improvements on the engineering side—the most striking being the doing

away of hand labor and introduction of labor-saving devices —it is to the commercial side that the gas industry owes the remarkable strides which have been made during the past ten years. A few of the conditions that have brought this about will be mentioned.

Under the commercial division is included the administrative work, which is mainly commercial, and upon which the successful conduct of the business largely depends. It is true that commercial functions are often regarded as being limited merely to the selling of gas. A moment's reflection, however, will show that this is far from the real situation.

Selling gas and the successful conducting of the gas business are widely different propositions. Before the realization of the possibilities of the gas business, by means of the development brought about by the necessity of increasing the sale of gas through the creation of a progressive business organization, commercialism was restricted to complacently accepting along the lines of mains already placed, applications of consumers, which applications were usually burdened with numerous conditions under which the supply of gas was furnished. The successful conducting of the business is now the primary object of the commercialism division. Within its province is included not only the commercial relations with consumers, but the finances, the accounting work, the purchasing of supplies, the shaping of the policies, and the organization of the various departments of the company. The public knows the company only through its commercial division. From the public view, the personal responsibility, as between the consumer and the company, of maintaining the quality of the gas at a proper standard, and the furnishing at all times of a sufficient supply at a satisfactorily uniform pressure, is upon the commercial division. This division, therefore, must accept the full measure of responsibility for the punctual and complete performance of all undertakings, and for the giving of good service, and any attempt to evade or shift the responsibility cannot be too strongly condemned. It is also charged with the duty of endeavoring to increase the output

of gas by developing new uses and by encouraging more extensive consumption of gas. This can be done properly only by careful and intelligent consideration of the needs and requirements of consumers, and providing them only with such service as will be found advantageous to them as well as profitable to the Company.

It will thus be seen that the successful commercial manager must, of necessity, have an insight into all phases of the business, and he has many intricate problems confronting him which cannot be reduced to a mathematical formula.

In a well organized company, the commercial side so marshals the forces of the business as to meet the just demands of the people for the most efficient and economical service, at the lowest cost consistent with such service, and at the same time fulfills the reasonable expectations of the stockholders of fair returns upon the investment and development of the business. The equitable solution of these problems, springing from the obligations to the individual consumers, the public and the investors demands executive commercial ability of high order and the incessant labor of a well organized and well directed organization.

In recent years, gas companies generally have recognized that it is essential that cordial relations exist between the gas company and the community it serves. This has brought about a better understanding of the business by the people, and it may be well to say a word or two about this aspect of commercialism. The troubles of gas companies have their origin usually in the same cause as most of the world's troubles—lack of knowledge. From this arises misunderstanding, indifference and absence of appreciation of the difficulties and of the achievements of gas companies, and under these circumstances there is very often no common ground upon which commercial dealings can be satisfactorily carried on. The public knowledge of the gas business, however, is greatly augmented by the patient process of stating and restating facts which eventually clear up many of the traditional fallacies of the gas consumer. It is the old story of the "po-

tency of an absolute fact." The individual habits of thought of gas consumers can best be observed through the operations of an elert complaint department, dealing, as it does, with every element of the community. We are all, in a sense, children when we act without thinking, and so it is with many belligerent and uninformed gas consumers. The idea that the gas meter is a swindling device which records far beyond the actual consumption of gas, and by some thought to be a "perpetual motion machine" that works day and night, whether the gas is used or not, is being rapidly dislodged by the intelligent and efficient work of progressive gas companies. In the last decade they have been advising gas consumers to *read their meters*—to regard the meter as an open book in which their account is kept. Here is a fact so obvious that for years it was regarded as being unnecessary to dwell upon. This suggestion has, after all, a reflex rather than a direct action in bringing about increased contentment among the consumers. The hammering home of this suggestion, apparently as unnecessary to make as that two and two make four, has caused only a very small percentage of gas consumers to read their meters regularly. It has been, on the part of the consumer, rather the knowledge of the willingness of the company to have the meters read than the actual reading that has given confidence in the mechanical honesty of the meter. The value of this confidence, of course, is increased if the consumer actually reads his meter regularly and always finds in the record a "square deal." As a matter of fact, the average gas consumer has neither the time nor the inclination to be educated as to the many helpful details of the gas business, but he does like the assurance that earnest effort is being made to keep the service up to the highest practical standard and maintain the rates upon the lowest business basis.

The public relations of a gas company also involve the consideration of good-will. The attitude of a gas company towards a community and the disposition of a community towards a gas company may be gauged by good-will. The

cultivation of good-will, in a commercial sense, is as necessary as the maintenance of the physical property of a company, and is one of the deciding factors in the success of the gas business. Whether good-will in itself is considered an asset, in a legal sense, or whether it is considered as enhancing the monetary value of the franchises of a company, there can be no doubt that it is of distinctly commercial value. That it is so regarded by progressive gas companies can be best illustrated by the fact that they are to-day spending large amounts of money over and above the mere maintenance of service by doing "gratuitous work;" giving extraordinary care to complaints, whether well founded or not; providing sub-stations for the accommodation of consumers; freely making extensions of service; and in many other ways going beyond strictly legal requirements in meeting the wishes of the community. If consumers receive courteous consideration and find the gas company always dealing fairly and liberally, they will, unquestionably use gas more extensively, and will not, because of dissatisfaction, seek to displace gas with other forms of fuel and light. The people may be depended upon to permit a gas company thus conducting its business to share in the increased earnings, if these result from the giving of efficient service and the caring for the interests of the community.

In any consideration of good-will it should not be overlooked that publicity is an important aid in bringing about a better understanding and creating more friendly relations with the public. Public opinion is generally healthy, and when the public is misled in an attack upon a gas company, it is usually traceable to the neglect of the company itself in not having taken reasonable precautions in keeping its consumers informed of its policy and methods. The press is a valuable ally and a potent influence in the commercial growth of gas companies. Nowhere is public opinion better understood or more heeded than in the editorial rooms of a newspaper, and nowhere will conscientious efforts of a gas company to improve its service receive more hearty response than from this

source. Through straight-forward advertising, through frank public statements and through aiding and facilitating the work of the press, much can be accomplished in preventing unreasonable, popular clamor and warding off unjustifiable attacks.

The scope of the American Gas Institute should be broadened and its activities extended towards popularizing gas companies generally by giving more attention to the commercial side of the business. No phase of the gas business should be emphasized to the disparagement of another, but efforts should be made to attain highest efficiency, not only along technical lines, but also by a full recognition of the commercial side of the business and the pervading influence of commercialism.

THE CHAIRMAN: You have heard the paper, and I hope you will give it a full discussion.

MR. PETTES: I would like to say that I fully agree with Mr. Cohn on his ideas in regard to treating the public. I think we ought to be particularly careful in selecting the men for what we call the complaint department. We should not only have men that are polite, but we ought to have sympathetic men, men whom the people will feel at home with, whom they will be glad to tell their troubles to and receive attention, and when they go away they will feel that they have been treated right and their troubles sympathetically heard. Take it home to yourself: Suppose you buy a ticket at a railroad office and the man is grouchy and when you ask him what time the train goes he tell you 1.15 right off the reel, nothing more. The next one you go to makes you feel at home. He tells you not only when the train goes, but he tries to be of service to you. I had just such an experience this morning. Such courtesy and attention puts the company in good standing with the community. There are men of that kind you feel at home with, and they are the ones we should select. They are not picked up every day, but that is what we are responsible for to get the right man in the right place.

MR. VON MAUR: I am particularly interested in this complaint man. He has to be a great deal more than simply courteous. The man who has to take care of complaints which happens to be my job in St. Louis, is very much handicapped by the manner in which the complaints are received. For instance, a man comes in wanting a service run, and he is apparently in a great hurry. The complaint man marks the order rush, and we spend a whole lot of money in filling it, and when we get there possibly the house is not half finished. A complaint of a leak is made. Everyone knows what is done in case of a leak. Everything else is dropped. Now by simply talking with that customer a little and asking him; "Where is the leak? have you noticed it for a long time? has it increased? etc." It may develop that it is simply a slight odor in the dining room, and he has been troubled with it ever since he has been in the house. Sometimes a complaint comes in the middle of the night, or right at quitting time, and sometimes we are compelled to send a man a great many miles to attend to it, and you can very well see the importance of a complaint man being something more than simply courteous, he must be intelligent.

MR. HANLON: Mr. Chairman. I would like to speak of an example of the true spirit of commercialism on the part of the solicitor. I do not like the term canvassing. I happened to be out with one of our representatives in a small town. He had worked faithfully all day, it was coming on late in the afternoon, and we were coming home. A party had a gas range that was in use. It happened to be early in the spring of the year when business was hard to get, and meeting this lady, she said: "I think my range has about given out and I will have to get a new one, I may as well give you the order." The man looked the range over and saw it was still a good one. The temptation was strong to take the order. He had not had an order that day. But he said to the woman: "You don't have to get a new range, that one is in good shape, and can be regulated, it won't cost you anything either." There

was an example of true commercialism. She said, "That is very good of you. I was going to get a new range, but I will take a hot water heater anyway; I really wanted both." It seemed that after that his luck changed, for he went down the street and sold two more ranges.

MR. LINTON: Mr. Chairman. In connection with this paper, I want to speak of our methods. In small places the solicitor and the inspector are one and the same. We have found this to be a very good idea in meeting with the electric competition, to combine the solicitor and inspector. That is a man who is capable of selling goods, but who primarily enters the home as an inspector of appliances. A day or two in advance of his going to a house he sends a card advising the people that at a certain time he will call to make an inspection of all the lights and appliances, and will put all those lights and appliances in good condition. He generally finds that some of the lights or appliances are not giving satisfaction, and by putting on new burners, new mantles or new tips or making some adjustments, he gets the good will of the people. They find it costs them nothing, and then while he is doing this work he makes a note of the appliances needed in the future, and if he does not sell at once, he has a good record for future reference. We find that works very successfully in a small place, and I imagine it would be equally successful in the larger places.

MR. JONES: Mr. Chairman. I think everybody knows that for a gas company, one of the best assets is the good will of the public, and the incident that Mr. Hanlon related of one solicitor having lost a sale by telling the woman she did not need a new stove, is one of the best policies that possibly can be adopted. If all gas companies would adopt that policy, of showing their customers what was the most economical appliance for their use, for example, if the solicitor should go around and find an appliance that is using more gas than is necessary to get good results, and should tell that consumer that he would make a trade with him by giving him some appli-

ance that would use less gas,—even if he had to take out a second-hand appliance, and put in a new appliance,—he would make a good friend, and show that customer that the gas company was striving to work in every way for his interest. Most up-to-date companies do that now. Another thing that some gas companies do and that some gas companies do not, is the returning of money for overread meters. That is one thing that I have found again and again gets the good will of the public more than any one other thing. If the customer's meter is overread one thousand feet or ten thousand feet, and as soon as the office finds it out, if they will return the money or return the customer's check for it, he will immediately say that gas company has given me the square deal; he is not waiting for my meter to catch up, and he is not keeping me out of my money. I know some gas companies that do not return money for overread meters, but they are not up-to-date companies. The most successful department stores are those run on the liberal plan of letting the consumer who buys the goods take them home, and if not satisfactory return them, and not haggle over it. All you have to do is to return the goods and get your money back. The gas company ought to do the same thing, and the sooner it is realized that the gas company has to do business on the same plan of a department store or any other kind of business, the greater and more speedy will be their success. It is their business to please the public, and the more you please the public, the more your business will prosper.

Mr. Gaston: Mr. Chairman. It has long been my belief that in order to increase the sale of appliances, and increase the sale of gas as well, that every customer should be familiar with the meter. He should know how the meter is constructed and how to read the meter. We have made a practice of distributing cards giving full explanations of meters, and also of impressing upon every customer the fact that we are anxious to have them visit our testing room, and we have made quite a success of it. Another plan we follow,

which is not, however, new, is to teach the school children how to read meters, and meters of all character, whether gas, electric, or water. You find meters in almost every home, of some description, and the children easily learn how to read them. I took the matter up with our Board of Education, and met with some opposition. I then went to the Superintendent of Schools, and he said it looked too much like commercialism; and that he was not there to help any particular business. I told him I thought he was there to help all business, and that I thought it was his duty to teach the children to read meters. But that it was not his duty to provide the means. We would do that free of charge. At an expense of about $150 we put in the hands of the 5,000 school children in our town cards with very simple instructions how to read meters. We also furnished each teacher with a mounted dial. I personally took it upon myself to get teachers to instruct the children how to read the meters. It turned out that only about four out of sixty teachers knew how to read gas meters, and the result has been that a great many of the parents are now reading the gas meters, that knew nothing about it before. We also impress upon our representatives the necessity of estimating the consumption of each burner, and to let the customer know approximately just how much gas is being consumed per hour. The result has been that we now have very few complaints.

The Chairman: A paper dealing with a specialty is discussed better before an audience composed of men interested in that specialty than when it is discussed before an audience composed of a large percentage of men who care nothing about that specialty. For the last three years the question has been up before the Directors as to the division of the meetings of this Institute into sections, each dealing with specialties. You can readily realize that a paper dealing with water gas or coal gas, their chemistry, or purification or distribution, or construction, or any one of a dozen other subjects I could mention, would attract a body of men just as much interested in those particular subjects as you men are

interested in the commercial side of the gas industry. It seems to me that this meeting here to-day points the way toward making a greater success of the meetings of the Institute.

MR. FITZGERALD: Mr. Chairman: I would like to move as a resolution that it is the sense of this meeting that the discussion of special topics by those specially interested in them is extremely desirable and profitable. (Applause).

The resolution was seconded, and unanimously adopted by a rising vote.

THE CHAIRMAN: At 2.30 p. m. there will be another meeting held in this room for the hearing of papers on Automatic Oiling Meters, the Booster System at Rochester, and the Acceptance and Interpretation of Data. After the adjournment of that meeting, all the members of the Institute will reconvene as one body in the large hall at 4 p. m.

MR. SEARLE: I would like to open the discussion on the subject of Commercialism again. There is one point that worries me. Mr. Hanlon mentioned the fact that a woman was told she did not need a new range. I do not know how old that range was, but she was evidently in the spirit to spend money, had to spend it, and I think if there was any spirit of commercialism in that man he would have sold her an up to date cabinet range, and sold the heater to some one that needed it more than she did. I would not have missed the opportunity to put a new range in that house. It is on the same principle that we are stopping at the Pontchartrain when we could get accommodations for 75 cents a day.

MR. HANLON: I do not want to let Mr. Searle get a wrong idea of this matter. This lady did not want to get a cabinet range. She did not want to spend more money to get the elevated type of range. We felt that the range she was using was ample for her purpose. She had a large family; and I think that as long as the appliance could be put in first-class condition, and would give her satisfaction, that our man was justified in advising her as he did. If she wants to

get another type of range, all well and good; that man can go back there later, when that range cannot be used and sell her the elevated type. Our men have sold a lot of the elevated type of range; I think they have sold as many of that type as any one of the large organizations. They are right after the business. Possibly the man was wrong, but the question was put up to him, and he acted according to his best judgment. He sold the woman a water heater anyway.

MR. CLABAUGH: I want to say something more on this question. I think the man did absolutely right. He was honest, and we all know that honesty is the best policy. When a man goes in a house and finds a range in a fairly good condition, that can be fixed up with a little adjustment or by repairs he does right in telling the consumer so. We have made a friend there. This woman may have been willing to spend the money, but she did not have to, she saved her money; she tells her neighbor of it, that neighbor tells another, and that solicitor has made friends with the entire neighborhood.

MR. SEARLE: As far as Mr. Clabaugh's attitude is concerned, it is absolutely honest. There is no doubt about it, but we do not know the conditions in the case, and we are dealing with an unknown quantity. Today, the public demands service; and that is what we are selling. A certain amount of fair commercialism could have convinced that woman, and honestly, that her range was a back number, and that a modern up-to-date range, a cabinet range for instance, would do her work easier, and better—I will not say better, but a little more comfortably, and the man with the proper spirit of commercialism would have sold her an up-to-date range, and would also probably have sold that second range to some woman down further on the same street.

MR. EAVENSON: What would be your idea in selling that second-hand range to somebody else, if it was not good enough for her?

Mr. Searle: Simply because many people cannot afford to buy a cabinet range; they have to work with some discomfort; they have to ride in the smoker, or the second-class compartment by force of necessity. Now, just as soon as that person can afford it, she will buy the cabinet type of range. We are selling lots of second-hand stoves to people who cannot at present buy a cabinet. I do not want people to think that simply because that woman has a range she is being served to the best advantage. I would not take the average 16-inch oven range, if you gave it to me. I would rather pay $60 for a modern up-to-date range, and the same holds good in every household. The solicitor must analyze every case very carefully in order to take proper care of it. He should exchange the maximum amount of service for the maximum amount of income. Now, as to teaching the people to read meters, as was referred to by Mr. Gaston; there again you are selling service. We make no attempt to reduce complaints—we go out and try to convince the consumer that he is getting good service, and show him that by reading the meter daily he is enable to keep daily track of the gas consumed. I would not, however, impose upon a small consumer by selling him a cabinet range, but I would sell him a new and better range if I thought it would be to his advantage.

The meeting was adjourned to 2.30 p. m.

Afternoon Session.

The Chairman: I will ask Mr. Walton Forstall to act as secretary of this meeting. The first thing in order is the reading of the paper on Automatic Oiling Meters by Mr. Thomas B. Miller, of New Orleans.

AUTOMATIC OILING METERS.

When the Fifth District of New Orleans, known as Algiers, had gas turned into its mains from a high-pressure pipe laid under the Mississippi River, in the fall of 1902, it was decided to install exclusively wet meters, there being several thousand

wet meters still in use in the City. It very shortly developed that these wet meters, in order to keep the gas supply on, had to be filled with annoying frequency, some of the larger consumers requiring attention two or three times each week. This was due undoubtedly to the extremely dry gas, result of compression to 30 odd pounds and consequent absorption of water from the meter while passing through it.

In the spring of the following year, a wholesale exchange of meters was made and nothing but dry meters installed. During the winter of 1903-04, it was discovered that there was an unaccountable falling off in the registration of most of the meters in Algiers. An examination of the meters showed that the leathers had had all of the oil extracted from them and that sufficient gas would actually pass through the pores of the leather to maintain one or two common burners. Examination showed these leathers to be in excellent condition, excepting that there was no oil whatever in them. Means of oiling the leather from the inside were devised, which proved quite satisfactory. Neatsfoot Oil, heated to 110° F., was used with some lampblack in it, the back plate was removed and oil placed in the inside of the leathers through the ports; the ports were then closed and the meter thoroughly agitated. After giving ample time for the leathers to become saturated the oil was allowed to drain out through these ports as best it would and what surplus oil remained filtered through the leathers and made Dipping Meters.

The ordinary oiled diaphragm will of course perform its prescribed duties and act in every respect in a thoroughly efficient manner, so long as the original oils, or substitute oils remain on the leather, and in this way render the leather pliable, gas tight, and at the same time preserve it in its original measuring capacity.

Under the action of certain kinds of gas the diaphragm oils are affected, and are entirely removed from the leather, without the replacement by substitute oils, producing what is generally termed bleachers.

To overcome this, a number of gas companies adopted to a greater or less extent the Dipping Meter which was a long step toward the preservation of the diaphragm and prolonging the life of the meter.

Experiments were made with the Dipping Meter and it was found that an oil of sufficient viscosity to serve the desired purpose would only travel high enough on the leather to take care of a 60 light diaphragm. This established a limit to the size of meter to which the dipping process could be successfully applied. There were other objections and limitations.

So long as the bottom of the diaphragm is merely dipping in the oil, the leathers will keep themselves in fairly good condition from capillary attraction. If, however, the oil is allowed to stand too high in the meter, it will pass through the leathers and fill up the bottom of the diaphragm compartment, which if filled to any extent by oil, would surely have effect on the whole meter and lessen the actual measuring capacity of the diaphragm.

Under certain conditions of the gas the tendency of the oil in a Dipping Meter is to absorb hydrocarbons rapidly and owing to the large area exposed increases the height of the oil in the case.

The oil ports at the bottom of the case must be opened and the surplus oil removed in order to preserve the accuracy of the meter. In order to do this these ports should be easily opened and closed to facilitate this work. With the standard form of construction of dippers, these openings can be unsoldered and re-soldered while the meter is in place, but this favorable condition gives the gas thief an opportunity to puncture the leathers, punch holes in the partition, or establish a by-pass which will pass as much as forty cubic feet of gas per hour on two inches pressure, and from a casual glance at the meter these conditions would not be discovered.

With appreciation of some of the objections to the dipping meter, the work of devising some means of oiling the diaphragm leather from the top was begun.

Laboratory experiments were made to ascertain the character of oil best suited to the purpose.

Mineral Oils For Diaphragms.

An oil suitable for oiling of diaphragms should be non-volatile, free from mineral and fatty acids, and of a degree of viscosity, which will allow the oil sufficient capillary power to keep the diaphragm oiled from bottom to top. Of these points, the question of acids is the most essential. A pure mineral oil may contain traces of free mineral acid, as a residue from the washing and distillation. Sulphuric acid is the acid generally used (when acid is used at all) and unless the oil is thoroughly washed, traces of this acid will remain and will prove detrimental to the life of the meter.

Neither animal, or vegetable oils, are permissible as a meter oil on account of the liability of free fatty acids, which are produced by decomposition of the oil. This decomposition is a more or less slow but constant reaction in these oils, hence free fatty acids may be present and may range in quantity from 1 to 80%, depending on the oil used.

These free fatty acids form basic compounds with the metal of the meter, resulting in deterioration of same.

Five samples of mineral oils were secured and results of work on these oils follow:

Sample	Color	Specific gravity at 60° F. direct Baume	Reaction acids fatty and mineral	Per cent. by weight of hydrocarbons absorbed from 10 cu. ft. of gas passing over surface of oil at rate of 1½ cu. ft. per hr.
A	dark red amber	.8978 26.0	neutral	13.69%
B	amber	.8992 27.4	neutral	17.80
C	amber	.8993 25.7	neutral	16.63
D	amber	.8478 35.2	neutral	17.06
E	dark amber	.9148 23.0	neutral	16.38

For capillary power, ½" strips of meter leather were suspended free in oil and the rise of oil timed.

Rise in inches	A Min.	A Sec.	B Min.	B Sec.	C Min.	C Sec.	D Min.	D Sec.	E Min.	E Sec.
½	6	30	3	30	13	30	4		15	
¾	13	40	9		38		9	10	40	
1	28	30	17	30	69		15	20	79	
1¼	50		29		107		25		135	
1½	80		48		150		35		180	
Inches in 48 hours—										
6⅛"			7½"		5¼"		Beyond 10"		4¼"	

B sample of oil was selected as having sufficient viscosity and the greatest diffusive quality.

Bits of leather were dipped in various grades of oil and suspended in a box exposed to the atmosphere of our Meter Shop for many months. The leathers still show satisfactory pliability and strength and the presence of oil almost to saturation. No evidences whatever of the quantity of oil having become reduced by contact with the atmosphere in rather a high temperature and no hardening or stiffening of the leather can be observed.

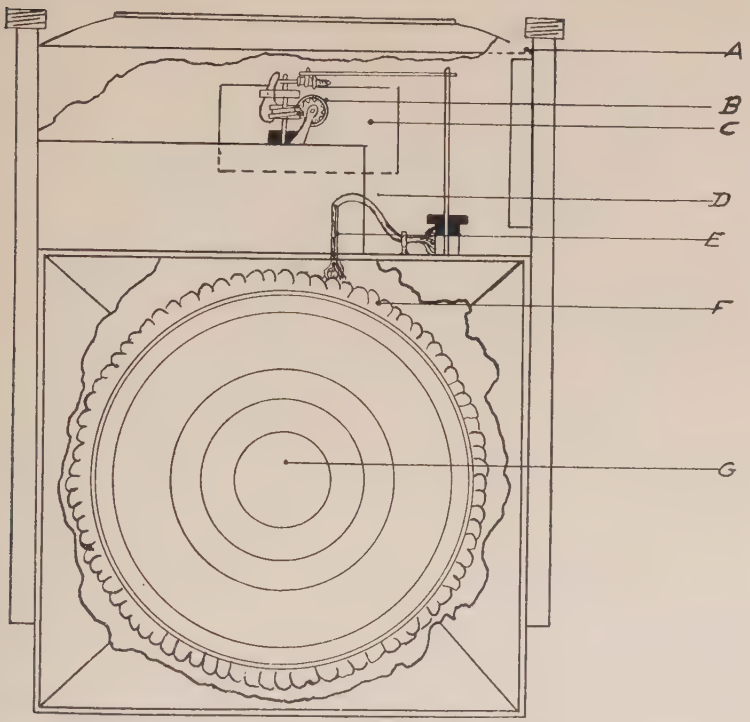
THE AUTOMATIC OILING METER.

Autoiler.

In the development of the Autoiler, separate chambers for the oil were tried and finally the top, or gallery, of the meter was utilized. This, of course, necessitated the enclosing of the meter dial in an oil-tight box so as to prevent the dial from becoming stained by the oil. The presence of oil in the gallery has beneficial effects. It keeps all the journals and the worm gear of the working parts of the meter oiled. It keeps the stuffing box of the flag arms thoroughly moistened with oil so that we have never had a leaky stuffing box from an Autoiler.

The presence of oil in the gallery as well as in the gas

chamber has a decided tendency to keep up the lubrication of



Rear view showing index inclosed and stuffing box for axle, also wickholder and wick.

INDEX.	
A.	Oil tube to table.
B.	Axle stuffing box.
C.	Index Enclosure.
D.	Wick.
E.	Wickholder
F.	Diaphragm.
G.	Disc.
H.	

the working parts of the meter and thereby causing it to operate with less loss of power. The oil vapor carried by the

gas up through the valves is sufficient to keep the valves oiled slightly so that there is no such thing as squeaking valves on any of the meters, even on the "A" and "B" type with the large heavy valves. No such thing as a cocked valve has been discovered in the Autoiler while we have frequently found such where the installation was of the standard type.

The oil is supplied to the diaphragm leather through a tube which passes just through the bottom of the gallery and extends up above the bottom of the gallery about the height of the back plate. A wick is strung in this tube with compression sufficient to make the flow of oil a desired quantity, this wick extending below the bottom of the tube with its ends frayed so as to come in contact with the top of the leather. The wick drops down into the oil where it is secured to the bottom of the oil chamber and the capillary action takes the oil up over the top of the tube, and the capillary action and gravitation carries it on down through the tube to the end of the wick where it deposits on the leather. This action will be more rapid when the leather is dry than when it is saturated with oil and with proper compression on the wick can be made to supply the oil so that it will completely oil the leather of the diaphragm in three or four months, thus insuring the fresh oiling of the entire leathers three or four times each year.

The pinion shaft from worm to the dial, passing through the dial box has a stuffing box which does not require to be tightly stuffed, only sufficient to prevent oil from passing through and then only such oil as may splash on the stuffing box in handling the meter. I believe that so far as the safety of the meter goes from tampering that it has all the protection an ordinary meter affords.

There is no possibility of gas by-passing from one side of the partition to the other through the oiling device if the wicks are properly strung. An effort was made to accomplish this without the wicks being oiled but no appreciable quantity of gas could be gotten through. With the wicks under proper pressure and no gas passing without any oil in the wick, it

is self-evident that when they became saturated no gas would pass.

The oil for the Autoiler should be inserted through a small hole in the corner of the top and a syringe of proper capacity will serve not only to place the oil there but measure it at the same time. If the space about this hole is properly guarded by a very simple device the possibility of successfully tampering with the meter is eliminated. The hole should be closed with a small rivet and drop of solder.

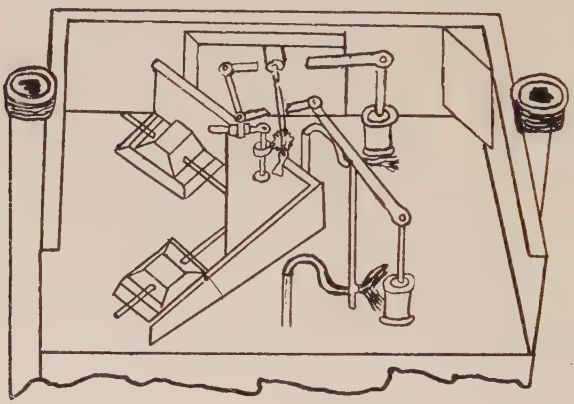
The first Autoiler that was made and put into service was placed in the Meter Shop. The leathers in this meter were installed perfectly dry and a glass side placed in the meter. The oil chamber was given a dose of oil and the meter placed in service. In 36 days the leathers were completely oiled and the meter then tested and adjusted. This meter has now registered over 700,000 cubic feet of gas and the leathers are apparently in as good condition to-day as when they were first installed. The accuracy of the meter is phenomenal in that every test it shows within a very small fraction of 1% the same degree of accuracy as when it was first started.

In our first experiment the meter oiled its leather in entirely too short a time, as no idea at that time had been formed as to how tight the wicking should be packed in the tube; but recent standard tubes and wicking, by experiments, show a perfectly dry diaphragm will become completely oiled in 36 days, and there is no doubt but that the flow of oil is more rapid and the capillary attraction more active on account of the leather being dry than it is after the leather became practically impregnated.

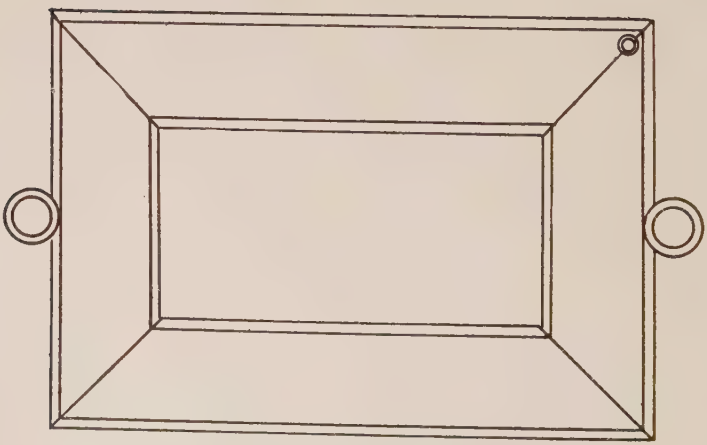
The Autoiling Meters it would appear can be given a dose of oil sufficient to keep the leathers oiled for from two to five years, thus not requiring constant attention removing surplus oil, shaking up, replacing oil, etc., etc.

The Autoiler may be handled in any manner, turned upside down, placed on the side, etc., without any danger, either in throwing oil on meter valves or in placing too much oil at one

time on the meter leather, provided the feed on the automatic oiler is properly regulated. It would therefore appear as



REAR VIEW SHOWING INTERIOR OF GALLERY



TOP VIEW

though this method were ideal in taking care of meter leathers, as proper regulation would give a certain predetermined con-

stant feed of the oil, at the point where it will do the most good, that is, directly at the top of the diaphragm.

RESULTS WITH AUTOILERS.

Fifty-three Autoiler Meters that had been in service from eighteen months for a few and six months for the larger portion were brought in and tested. When put into service

18 were fast an average of..... .94%
27 were slow an average of..... .89%
8 were exactly correct, all as per prover records.

Upon return to the shop for test, removals having been made for specific purpose, none having come in for defects of any character showed

27 were fast an average of..... 1.23%
14 were slow an average of..... 1.30%
12 were exactly correct, all as per prover records.

The maximum error of meters going out was 2% fast and 1.98% slow.

The maximum error of meters coming in was 5.26% fast and 2.44% slow.

The average error of all the meters going out was 0.127% slow.

The average error of all the meters coming in was 0.486% fast.

The aggregate consumption on the fifty-three meters was 3,042,200 cubic feet, an average of 57,400 cubic feet per meter, with a maximum consumption on any one meter of 684,800 cubic feet which meter tested 1.43% different from its test when set.

The minimum consumption on any one meter was 6,000 cubic feet.

Eight months ago there were installed in the City approximately 600 Autoilers. The 53 meters described are all the Autoilers handled into the Shop since May 1st of this year.

THE CHAIRMAN: Now gentlemen, this is a paper in which every gas man in the United States is interested. We have to have meters, we have to keep them accurate, and we have to keep the diaphragms in order. If any members wish to add anything, or to dispute anything, we shall be glad to hear from them.

MR. HARDICK: Gentlemen: Several years ago we started in with the dipping meters. That is, we punched a hole on the bottom, on each side of the diaphragm, and inserted our oil there. In removing the meters for testing we found them to be in very good condition, in fact, the leathers were in about the same condition as when installed. Now, in regard to the self-oiling meters, upon which this discussion is based, I think we have some twelve of them installed. They have been out practically eighteen months and have not been removed. I wish some one who has had experience would give us a little information as to how long the oil will last in the top of the meter, and also, what means they have for re-filling the meter without removing it to the shop. Of course, you can take a soldering iron and unsolder the meter at the top, but there is danger in that. A few more years experience will tell us the result of this practice as it is only in its infancy at the present time. I would like to hear from some one who has had experience with dipping meters or self oiling meters of more than two years; I think we would all be interested in them.

MR. W. A. CASTOR: The dipping of meters has been practiced in Philadelphia for the past four years there now being more than 200,000 meters of this class in use in that city.

The oil is introduced direct into the diaphragm chambers and picked up by the diaphragms as a result of the capillarity of the leather. There appears to be but one objectionable feature in connection with this practice—that is, the tendency of the light mineral oil to penetrate the seams and corners at the bottom of the meters.

Extensive experiments made to determine the largest meter that could be made dipping with the assurance that the oil will travel to the topmost portion of the diaphragm, showed that we were perfectly safe in including the 300-light meter, the oil rising faster in the diaphragms than it did in straight strips of leather, to the height of the top of a 300-light diaphragm.

Our experience has shown that the presence of oil in the bottom of the meter does not tend to pull down condensation, —that the condensation does not accumulate to such a depth as to affect the registration,—that no tampering is done, by the consumer, to the rivets soldered in the oiling holes punched in the side of the meter,—that proper oil absolutely free of acid can be readily obtained, and that said oil does not become rancid with age.

I cannot see where the method of putting oil into meters as practiced by Mr. Miller, has any advantage over the scheme in general use in Philadelphia and in many other cities, but on the other hand presents to me the following objections:—Expense of encasing index mechanism, of providing oiling tubes and wicking for same, presence of gas under the top of the meter, the inability to determine the rate at which the oil is conducted from the table to the diaphragms, necessitating unnecessarily frequent trips to the consumers' premises to renew the oil periodically, or else taking a chance of the oil all being carried away leaving the diaphragms free to become bleached as soon as temperature conditions are suitable to produce bleaching,—the disadvantage of removing and of resoldering the top rivet in oiling hole at consumers' premises when recharging meter, and the needless use of oil in the top after the oil has reached a sufficient height in the bottom of the meter to enable the diaphragms to dip into same, thereby making the meter a true dipper.

Mr. Searle: The little things that cause annoyance or the danger of occasioned theft should not lead us to give up the dipping meter or the self oilers. The thief will beat us

now and then, no matter what precautions are taken. I do not think the rivet hole in the meter will attract the average thief. I know some of us are apt to discard a good thing—and both of these are good—because some one may steal gas. Well, I would not let a few thousand feet of gas deter me from having a few thousand meters accurate.

MR. RICE: One very important fact is that these methods have the advantage of allowing the meter to take care of itself, and that should strengthen us in our effort to get away from the idea of pulling out the meters periodically, just because we think there may be something wrong in them. We want to be strong enough in our conviction that the meters are right and able to take care of themselves, to impress it upon the legislative bodies and commissions that are formulating rules on this subject. In Wisconsin, for example, a commission has decided that all meters must come out every three years. Now, we all know that a meter that has been in three years, and is doing good work, and properly cared for, is in better condition than it was the day it was set. It is a shame to take that meter out just because somebody thinks it may be wrong. It hurts the meter to take it out. It does it much harm. Years ago in one of the largest repair shops in the state of Wisconsin the tests showed that between 70 and 80 per cent. of all the meters removed for tests were correct within the required limits. I have no doubt the ratio maintained to-day is still higher and if this new method brought forward by Mr. Miller will increase the life of the meter it should receive our approval. There is one feature that I did not understand. Is it a fact that the auto oiling meter can be transported without difficulty, and can be turned upside down? I believe that is not the case with the dipping meter.

MR. CASTOR: Reference has been made to the fact that meters may be turned upside down with perfect safety. We are extremely careful to impress upon our employees that they should never under any condition be turned upside down.

dipping or non-dipping. We cannot safely fill our meters with oil for transportation, but when we do repair work for companies outside of Philadelphia, the holes for introducing the oil are punched in the outlet side of the meter and the proper rivets soldered in same. When the meters are received from the repair shop, it is a simple operation to remove the rivets with a soldering iron, introduce the proper quantity of oil into each diaphragm compartment and then replace the rivets in the holes.

Mr. Rice: May I inquire how you can depend on the proof of that meter if it is filled in a local shop.

Mr. Castor: A number of experiments made to determine the change in proof of meters removed from service and of meters that have been cleaned and oiled, or new diaphragm repairs, show that the oil introduced into the diaphragm chambers does not materially alter the proof of meters that test within reasonable limits of error upon removal from service, and effects the proof of repaired meters to such a small extent as to be negligible.

Mr. Forstall: As bearing on what Mr. Rice has said about sticking by your meter and the foolishness of changing them every three years; we have in Philadelphia followed the practice for the last five or six years of not changing the meter simply because it has been used three or four years, but if the bill for the quarter is less by more than 33 per cent. than the corresponding quarter of the year before, they make out what we call a house test card, which is sent to the shop, and the shop sends out and makes the test of that meter on a small flame. If the meter does not register on a small flame we take the meter out, and we find as a rule it needs to be taken out. We have made about 20,000 house tests, in the past year, and out of those 20,000 tests I do not believe we have brought in more than five or six thousand meters.

Mr. Rice: That is very interesting to me, because a year ago we started in on the same idea, and we are now getting the system pretty well developed. The ledger clerk

is going over our ledgers and comparing the bills for two and three year periods.

Mr. Castor: We are keeping a very careful record of the tests upon removal from service, of all meters, both the dipping and non-dipping. The tests are tabulated according to the number of years the meters have been in service at the last address. From this record we expect to definitely determine the maximum number of years the meters may be allowed to remain in service as reliable measuring devices.

Mr. Miller: I do not understand what Mr. Castor means by the presence of gas under the top of the meter. There is nothing of that kind. There is no gas gets through that wick. That was brought out in the paper. There is no occasion to watch the meter to see if the oil remains in the top to insure accuracy. If the stringing of the wick should be so imperfect as to let that oil through in six months as has been the case in some instances you have a dipping meter and we are right back where we started before we got the automatic oiler. In regard to Mr. Searle's remark that the thief is going to steal anyway, I don't mean that a man is deliberately a thief, but the opportunity often makes a thief, and the opportunity offered will often be taken, when if it was not there it would not be taken. I do not know whether my community is any different from others, but we have had a good deal of such experience. I do not know whether this auto oiling is an ideal thing or not, but I think the advantages it offers are brought out in this paper. I had a great many of these meters that came in after having been in use for some time and registering up to 30,000, 40,000 and 50,000 feet, and we found them all right. I heard Mr. Brown remark at the meeting last year that one trouble he was having was that successive tests were unreliable. The successive tests produce an abnormal condition, which causes a great deal of trouble while using air. Therefore, he used gas afterwards. I have two records here where we made five successive tests, one right after the other. The first test showed .050; the second test showed nil; the third

test showed .050; the fourth test showed .050; the fifth test showed nil. Another one was 3 per cent. fast, the second test showed 4.17; the third test showed 4.15; the fourth test showed 4.17. We have tried that time and time again on meters, to find out if there was going to be any change from the introduction of air. The fact that the introduction of air in that meter does not change the tests is the best evidence in the world that your meter is in good condition to handle any kind of gas you may make, whether it is absorbing or giving out oil; if the oil is going out you are supplying more all the time. If the oil is coming in there, I will admit, you are going eventually to have a dipping meter, but in the dipping meter if the oil is taken out it is gone for good.

THE CHAIRMAN: Our time is limited, and I will call upon Mr. Luqueer to read his paper on the Acceptance and Interpretation of Data.

THE ACCEPTANCE AND INTERPRETATION OF DATA.

The acceptance and interpretation of data broadly considered covers every field of human endeavor; the physician in his diagnosis, the lawyer in the examination of witnesses and the preparation of his case, the engineer in the solution of his problem, the business man in his trading, the farmer in the cultivation of his land; and so on through the whole range of activities that demand the exercise of man's power of reasoning.

Data may be defined as a collection of facts either indubitably known or treated as such for the purposes of a particular discussion. In this definition, we have in large measure the explanation of the fact, that, in the industrial world, it is the man of experience who commands, for, by reason of his exact knowledge, he readily accepts or rejects data with certainty where another must assume.

No matter what the breadth of experience, however, there is no escape from assumption in many of the problems that

present themselves, and perhaps the most important and difficult problems because of this very fact that the premises are not, and cannot be, indubitably known. Obviously, no correct conclusion can be deduced from incorrect premises (except by the merest chance) nor will the best of data avail if it is misinterpreted.

No doubt this is well understood and appreciated and it may, therefore, seem presumptuous to come before this Convention to urge care in the acceptance and interpretation of data and yet that, in part, is the purpose of this paper and it finds its justification in the many evidences of lack of care and disregard for the truth, frequently so apparent that "he who runs may read," but more often only disclosed upon analysis and verification.

Recently a set of experiments were conducted by four men of unquestionable ability in their respective lines, three of them known to many of you, and one a member of this Institute. The results were testified to over their signatures, great stress being laid upon the care with which the tests were made, and yet the sampling was done in such a manner as to render the tests as a whole practically worthless. The fact that the conditions were peculiar and the provided means for sampling so entirely plausible may serve as an excellent excuse, but it is small consolation to the client who has paid for expert services, presumably in order that he may not deceive himself and others. Then, too, excuses are damaging to reputation which is a possession well worth every effort made in behalf of its preservation.

Another apt illustration of failure in verification may be found in the evidence in the recent case of the Consolidated Gas Company of New York, which, by the way, discloses many instances of the acceptance of faulty data. The testimony in the examination of a witness for the State of New York reads as follows:

"Q. From your experience and from your investigation as to the cost price of other modern and up-to-date companies,

what would you say it would cost an efficient, modern plant, efficiently and economically managed, to produce gas and put it in the holder in the City of New York?

A. Considering the immense amount in New York City of gas and the prices prevailing here as shown in the accounts of the companies which I have looked over, and comparing it with the results and apparatus of a similar kind in other cities, I think the price cost per thousand could be reduced to 24 cents.

Q. For a 22 candle-power gas?

A. Yes sir."

Upon cross examination, the record continues:

"Q. Will you name any city where the gas is produced at 24 cents in the holder, including repairs and expenses and distribution as to works, as well as labor, and material and enrichment, and so forth, up to the holder?

A. Yes, I think that if I remember rightly, New Bedford has as low a price as 24 and a fraction.

Q. You do not claim they maintain 22 candle-power in New Bedford, even on the average or usually?

A. I don't think so. If I remember rightly, they maintain 18 or 19 candle-power.

Q. Now will you be good enough to divide here this 24 cents which you have said should be the cost in New York, indicating how much should be the cost for coal, how much for oil, how much for labor, and the other elements that go to make up the cost in the holder?

A. Well, I made this cost up from operations in other cities ....I will have to take time to make up such a statement as that.

Q. You do not mean to say that you have given this 24 cents without making up a statement?

A. As far as that is concerned, I had the prices of those other companies in view, and being smaller and some of them not as well situated as New York, I had a right to assume that they could do as well in New York ....."

Further questioning failing to reveal the names of any of these "other companies" aside from New Bedford, the basis for this assumption seems somewhat meagre but dwindles to insignificance in view of the actual conditions in that particular city. Investigation developed the fact that the New Bedford Gas and Edison Light Company had never produced its gas at a cost even closely approaching 24 and a fraction cents per thousand feet in the holder, nor could the records of the Company in any conceivable manner be construed as having shown such a low cost. The evidence of the witness thus becomes valueless; the manner in which he may have been misled is indicated later in the testimony in rebuttal by one of the witnesses for the Consolidated Gas Company, whose explanation passed uncontradicted and is as follows:

The report of a Special Committee to consider the London Sliding Scale was issued not long previously and contains a table giving certain data prepared from the returns of the Massachusetts Companies to the Board of Commissioners. Among others, there are two adjacent columns in this table, one headed "Cost of Production per M. Feet Sold" and the other "Cost of Distribution per M. Feet Sold;" and it so happens that, in the case of New Bedford, the amounts in these two columns are transposed, the cost of production per M. showing as $.254 and the cost of distribution as $.3865, whereas, the latter was the cost of production and the former the cost of distribution. The 25.4 cents per M. feet sold would reduce to 24 and a fraction cents per M. feet made.

The State's witness, however, having committed himself to 24 cents per thousand for the cost of 22 candle-power gas in New York proceeded to make up a statement to show in detail how it was to be accomplished. The attempt to bolster up a preconceived conclusion based upon such flimsy data led from one mistake to another and resulted in a veritable comedy of errors. As the witness expressed it, the gas was to be "almost entirely composed of 14 candle-power coal gas, and to that we add oil gas enough to restore the candle-power

to above 22 candles and enough water gas to carry the oil vapor through the superheater."

Before the cross-examination had proceeded very far, the whole calculation was in confusion; an entire page of the printed record is devoted to the difficult problem of dividing 10 cents by 10600 feet in order to obtain the cents per thousand with results ranging from .094 of a cent to 9 cents, and the witness did not know whether his calculation was based upon a mixture of 225 cubic feet of oil gas and water gas with 775 cubic feet of coal gas or upon 225 feet of oil gas and water gas mixed with 1000 feet of coal gas. It may seem incredible that, in a case of this character, the record should become burdened with such testimony and, while it makes interesting and amusing reading, some one must "pay the piper," and the heaviest share, unfortunately, more often than not, devolves upon the Gas Company.

To proceed, this witness—one hesitates to say expert witness—was given an extension of time in which to disintangle himself and finally produced the following as the cost of 1000 cubic feet of 14 candle-power coal gas for New York.

"Soft coal $3.20 per ton of 2240 lbs.; average yield 5 2/10 cu. ft. per lb.—11,648 cu. ft. per ton coal.

	c.
Cost for coal $\frac{3.20}{11648} =$	27.47
" " unloading $\frac{11.2}{11648}$ per ton = ...	.961
Cost for labor, gas-making and purifying:	
Cost labor per ton .522.....	4.48
Cost supervision—superintendent and foreman	.50
Cost repairs to apparatus—building.....	3.50
Cost purifying material—lime 56 cents per bu.—23 M. c. f. per bu.....	.75
Cost purifying material—oxide	.25
Cost oil and waste and sundries	.37
Cost water	.17
Cost general expense at works.....	.50
	38.951

Less Residuals—			
For 66% coke and breeze	1478. lbs.		
Less 20% for firing retorts.....	295.6		
	1182.4 lbs.		
Salable, at $4.00 per ton 2000 lbs.	$\frac{2.3648}{11648}$	c. 20.31	
Tar 13.45 gallons at 5 cents....		6.72	
Ammonia liquor, $\frac{56}{11648}$		4.80	
			31.830
Cost			7.121"

The above statement is given at length not as an illustration of the acceptance of questionable data, though much might be said in this direction, but for another purpose.

At present there seems to be a lull in the investigation craze that was so prevalent a few years past, nevertheless there is a tendency toward the spread of Public Service Commissions, and it is more than possible that not a few of us may be called upon to meet testimony similar to, if not quite so outrageous, as that which has obtained heretofore. It may not be amiss, therefore, as opportunity offers, to call attention to the advantage of considering a proposition from every point of view and, at the same time, to present a striking illustration of the manner whereby conclusions based upon faulty data may often be shown to be practically absurd without the necessity of refuting in detail the data itself. Detailed refutation is sometimes difficult; time is likely to be limited and sources of information remote, and we find ourselves in sympathy with the saying that a "Lie travels round the world while Truth is lacing his boots."

Referring then to the above statement of cost per thousand for coal gas and bringing together the cost given for coal and the return for residuals, we have:

	c.	
Cost for coal	27.47	
Cost for unloading	.961	
		28.431 cents per M.
Less Residuals:		
Coke	20.31	
Tar	6.72	
Ammonia liquor	4.80	
		31.830
Coal less Residuals a *Credit* of		3.399 cents per M.

As was well known, any credit for coal less residuals was something practically unheard of on the Atlantic Coast, to say nothing of a credit of nearly 3.40 cents per thousand —as a witness for the Company stated—under the then present conditions, it was a physical or financial impossibility, whichever way one cared to express it.

Qualification and definition are further matters to be considered in connection with the acceptance of data. Even carefully prepared and valuable records are at times far from self-explanatory.

Recall, for example, the case cited in a paper presented at the meeting of the New England Association of Gas Engineers in 1907, with reference to a certain column headed "Capital per M. Sold Including Bonds," in an Annual Report of the Massachusetts Commission. It was found that in addition to Bonds, "Notes Payable" were also included, and, thus qualified, this statement of fixed capital was the means of showing that the working capital of certain Massachusetts companies, instead of being 13 cents per thousand of annual sales, as claimed by a witness in the New York Consolidated Gas Company case, was more than three and a third times as great.

Having finally accepted properly verified data, and with a

full understanding of its particular conditions and limitations, the knowledge that it is complete and sufficient for the purposes of its use is an additional requirement.

Under certain circumstances, insufficiency leads to consequences quite as serious as those resulting from inaccuracy.

An engineering company of recognized standing, with many large and successful undertakings to its credit, was retained by certain capitalists to prepare estimates for a large hydro-electric development.

All available records as to the stream were secured, surveys were started and the work of obtaining other accurate and necessary data was begun.

The situation seemed full of promise, the financial interests were optimistic and impatient and the engineers, pressed for time, completed their estimates basing them upon the incomplete information already in their possession. A company was organized, financial arrangements made to cover the estimated expenditure and construction work was commenced.

Briefly, the outcome was a receivership; the amount called for in the original estimate having been spent, it was estimated that something approaching 75% in addition would be required to complete the development. It is fair to say that not all of this excessive discrepancy was due to errors of estimate, a considerable loss being sustained by reason of division of responsibility for the construction work, a condition, by the way, to be studiously avoided if possible.

In the recent Fall River pressure case before the Board of Gas and Electric Light Commissioners, the petitioner was the Mayor of the City and the contention was that pressures in the mains had been so increased that consumers had been "obliged to use an amount of gas beyond their needs" and that, therefore, former reductions of price had been of little or no value to the consumers.

The following is quoted from the decision of the Board:

"The petitioner based his contention upon the following

facts: In the seven years from 1898 to 1905—the years used for comparison by the petitioner—the annual sales had increased from 122,496,980 feet to 321,119,341 feet or 162 per cent.; that in the meantime, the length of mains had increased 79 per cent., although the average diameter had been increased less than 7 per cent., 24.9 per cent. of the total length in both years being 6-inch mains or smaller; that the gas lost per mile of main had increased 96 per cent. between 1898 and 1904; and that, while the number of 3 and 5 light meters had increased from 47 per cent. of the total capacity to more than 96 per cent., the sales per meter light had increased 29 per cent. These facts were not disputed. Considered by themselves alone, they appear consistent with an increase of pressure; and if there were no other facts of greater importance, they might fairly lead to the conclusion that pressures had been substantially increased during the period named."

Here then we have another illustration of incomplete data for it was shown, on the other hand, that during the period under consideration, the number of consumers had increased "from about 5000 to 15000, and the number of gas stoves installed from about 4000 to upwards of 15000;" and, furthermore, the average consumption per consumer was less in 1905 than in 1898. Upon these and other additional facts, which need not be cited here, the Commission very properly concluded that the complainant's contention was not sustained and dismissed the petition.

A most amusing instance of acceptance and interpretation of data occurred in the trial of the Cedar Rapids case not long ago. The evidence of a witness for the city, testifying in regard to leakage and the leaky condition of the holder in particular, is quoted as follows:—"There were any quantity of white markings there and I didn't care to touch a match to them. . . . I never made a specialty of detecting leaks in holders and don't know how gas men detect them. I know the holder is in bad shape."

As the Company was able to offer positive testimony that

there were no leaks in the holder and that the damaging evidence of this "expert" in the form of discolorations had been largely furnished by a flock of busy sparrows, the effect on the court can well be imagined.

If carelessness is reprehensible in the matter of acceptance of data, then certainly it is to be condemned in the matter of interpretation. Interpretation displays either knowledge, ignorance or carelessness—it is here that right thinking is essential and "a little knowledge is a dangerous thing."

Most of you will probably remember the apt illustration of this given in the lecture on electrolysis before this Institute in 1907. Professor Ganz referred to a published report upon a water piping system where the total current between pipes and rails through ground is given as 6,148 amperes, resulting in a calculated destruction of 122,960 pounds of iron per year. The current was determined by measuring potential difference with a voltmeter and resistance with a ohmmeter between a point in the rails and a point in the pipes, and calculating the amperes from Ohm's law, the operation being repeated at a series of points and the sum of the currents given as the total current through the ground. Here we have an absurdity as the result of misinterpretation of data which in itself was very probably entirely correct. The fact that the result was absolutely without meaning was shown in view of the facts that "many times the current could have been obtained by making tests in a sufficient number of additional points in the system" and that the ground resistance "is the joint resistance of all conducting paths between the entire piping system and the entire rail system, while the potential difference is that between a point in the pipes and a point in the rails" the measurements as made "can therefore not be combined by Ohm's law to give current."

In connection with his discussion of this matter, Professor Ganz stated that the technical press had "already exposed and severely criticised some of these reports which have been published."

The technical press is a powerful agent in exposing numer-

ous fallacies that are promulgated; in this and many other directions, it is a large and valuable factor in our economic development and any consideration of the acceptance and interpretation of data would be incomplete were such a vast source of information overlooked. The technical journal in the ordinary performance of its functions is the vehicle for opinions and conclusions of individuals, for which it is not and cannot be expected to be responsible; it is not unusual, therefore, after having spent valuable time in the study of some article of contemporaneous interest to discover in the light of personal knowledge or analysis errors of fact or of interpretation tending to undermine the entire argument.

In January last, for instance, there appeared in one of the gas journals an article entitled "Per Capita Sales of Gas," in which we find it stated that—

"From a population of 2,000 to 75,000 the sales per capita appear in most instances to depend almost entirely upon the price of gas, regardless of population. Above 75,000 the sales per capita appear to be decidedly dependent upon the population, increasing from an amount fixed by the density of population as the price of gas is lowered."

Later the following statement and table appear:—

"While the increase of sales per capita appears to be about 50 cu. ft. for each cent reduction of price in towns selling at from $1.25 to $1, it will be seen that the average increase in cities is about 40 cu. ft., although their average sales per capita is greater than in towns.

Massachusetts Towns	1907 sales per capita c. f.	Sales per capita and date year	Sales per capita and date c. f.	Difference c. f.	Gain due to time yrs.	Gain due to time c. f.	Gain due to reduction cts.	Gain due to reduction c. f.	For 1 cent c. f.
Lynn,	5404	1903	3616	1788	4	960	15	828	55
Lowell,	5043	1901	3352	1691	6	1440	6	251	43
Cambridge,	5465	1905	4504	961	2	480	10	481	48
Springfield,	4209	1905	3491	718	2	480	5	238	47
Fall River,	3957	1905	3036	921	2	480	10	441	44
Worcester,	3853	1905	3205	648	2	480	11	168	15
Lawrence,	3619	1906	3229	390	1	240	4	150	38
New Bedford,	3088	1905	2233	855	2	480	11	375	34
Average,	4330							Average,	40

In the statement just preceding the table, there is a differentiation between "towns" and "cities," and while the first column is headed "Massachusetts towns," no doubt the word "cities" is intended, these places having been purposely selected on account of the fact that they all exceed 75,000 in population, with the possible exception of New Bedford, which is shown as approaching this figure very closely.

The data which forms the basis of the main argument is found in the Reports of the Massachusetts Board of Gas & Electric Light Commissioners, which are highly commended in the article for their clearness of statement.

Reference to these reports shows that in the above table the "1907 sales per capita" are derived by dividing the sales for the year ending June 30th, *1907*, by the population according to the census of *1905*, and further that the 1905 sales per capita given in the fourth column of the table for Cambridge, Springfield, Fall River, Worcester and New Bedford, and the 1906 sales per capita for Lawrence, are also based upon the census of 1905. Hence for all of these six companies changes in population are entirely eliminated, a constant divisor being applied for 1905 and 1907 in each case, notwithstanding the statement quoted above that for cities of this size "the sales per capita appear to be decidedly dependent upon the population."

In one case, the constant divisor is used although the records clearly show that between the dates under consideration the Company had enlarged its territory.

Correction for this and at least five other errors of omission or commission in the table, aside from the matter of constant population, results in at once reducing the average cu. ft. for 1 cent from 40 to about 30. This 40 cu. ft. increase of sales per capita for each one cent reduction is characterized in the article as nothing "more than a rudely approximate commercial quantity" and with this qualification we can almost agree, provided that the term "rudely approximate" is liberally interpreted.

In the column of the table headed "Gain due to time," it will be noted that a constant of 240 cu. ft. has been multiplied in each case by the elapsed time. This constant of 240 cu. ft. is the result of preceding tabulations with reference to which the author says that he has "omitted the laborious computations of the above tabulations as requiring too much space, but as the method is stated they can be verified by anyone." A glance seems to indicate that again the sales for the year ending June 30th, 1907, have been combined with the 1905 populations and in view of the errors already disclosed, one is scarcely encouraged to undertake the "laborious computations" referred to as necessary for verification, nor willing to accept the conclusion without verification.

In the January 15th issue of the journal referred to, there is an article entitled "London Sliding Scale for Gas" written by the author of "Per Capita Sales of Gas." After a statement as to English conditions and the "Utopian miracles" apparently wrought by the sliding scale in England, we come at length to the heading "General Theory of the Sliding Scale" under which there will be found a copy of some of the tabulations appearing in the former article and ending with the following formula "for the average total gain in sales resulting from a reduction in the price of gas and the lapse of time, in similarly situated cities." Similarly situated cities here refers to the eight cities covered in the table given above.

$$Z = \frac{(240 + 40r)\, y\, p}{1000}$$

in which

Z = total increase of sales in thousands,
y = number of years considered,
p = population served,
r = reduction per 1000 cu. ft. in cents of price of gas.

The 240 cu. ft. and 40 cu. ft. are the two constants already discussed but the qualification as to either being a "rudely approximate commercial quantity" is lacking.

The use for this formula is indicated in subsequent equations which include the quantity Z; one of these, for instance, is called the "General Equation of the Sliding Scale" and is as follows:

$$\frac{(C + B)}{(S + Z)} \times \frac{(a + rx)}{100} = p - c - r.$$

in which

C = the total valuation of works or plant in cents.

B = total cost in cents of extensions or additions to capital required to meet increase of total sales, Z.

S = the total annual sales in thousands.

Z = total increase of sales in thousands, as before.

a = the agreed standard dividend (per cent.).

x = the per cent. increase of dividend for a reduction of one cent in price to divide equally the saving in cost of gas, or in the reduction of investment, per 1000 cu. ft. sold.

p = the standard (or initial) price of gas per 1000 cu. ft. in cents.

r = the reduction in price of gas per 1000 cu. ft. in cents.

c = the agreed cost of gas per 1000 cu. ft. delivered in cents.

Relative to this, the author says "If in this equation, we place the condition that the reduction of price (r) to the consumer shall equal the increase of dividend....we share the saving in cost of gas equally." This equal division between producer and consumer is the basis of the author's sliding scale which in his language "can be applied to every conceivable case because it embodies all the factors naturally operating upon the finances of gas works."

The particular case of the Boston Consolidated Gas Company is considered, values are assumed for (C+B), (S+Z), a, p and c in the above equation, and while the data assumed is inconsistent with the author's professed theories in some respects and, in others, apparently is in need of modification, the difficulties are thus easily disposed of so that r, the reduc-

tion in price, and x, the per cent. increase of dividend, are readily solved and a tabulation made satisfying in each case the condition of equal division.

When, however, it comes to the practical application to "every conceivable case," it is by no means so easy to satisfy the equation since such unknown quantities as the cost of gas, the total cost of extensions required to meet increase of total sales and the total increase of sales—the first two more or less dependent upon the last—must all be estimated in advance.

There is supplied the formula for determining the total increase of sales only, and this formula is decidedly limited as to scope by stipulation and from what has been shown heretofore probably of little value in any event.

It would rather seem then that the author's expressed hope that he has cleared up "this tangled situation, reaching an equitable and universal sliding scale" has hardly been realized.

Concluding the article, there is a prophecy to the effect that "the triumphant progress of the sliding scale in England will be repeated in America."

In view of this, but more especially because of the manifest interest in the subject of the sliding scale at the present time, it may be appropriate and within the scope of this paper to briefly state the opinion of an English Barrister at the Parliamentary Bar, who is also a member of the Institution of Civil Engineers, a Director in six or eight gas companies, as well as some time engineer of one of the largest English Companies.

Comparing the advantages of the methods known as the "Maximum Price" and "Sliding Scale" respectively, this gentleman is all in favor of "Maximum Price with Auction Clauses" in preference to the "Sliding Scale," with reference to which he writes as follows:

"Like many superficially attractive ideas, the principle is bad in practice.

"The two most difficult things that a Gas Administrator has to do is,

(1) To add to the dividends of the proprietors,

(2) To reduce the price of gas to the consumers.

"Either one of these tasks is always onerous, and it is, therefore, from the writer's point of view, an ill-advised thing to make them synchronize, or, in other words, to ask the Administrator to do two very difficult things at the same time.

The effect in practice frequently is to defeat the object of the system by compelling the Administration to refrain from either, because both parties to the arrangement have the right of simultaneously insisting upon their share of the benefit due to the operation.

A second objection to the system is that it is always disturbing the current values of stock in the market by the continually changing rates of dividend, and those who buy stock at an enhanced price due to a temporarily high dividend, are naturally dissatisfied when in the normal operation of the sliding scale the dividend falls and the value of the stock with it. Moreover, they cannot escape from the Company excepting at a loss, until the stock has regained the enhanced value at which they bought it, and thus the marketable character of the stock is affected. It may sound childish, but it is true, that the normal conception of the investing public of any such scheme as the sliding scale is that their dividend is always going to increase under it, never diminish.

"A third objection, which although the least apparent theoretically is perhaps the most serious in practice, is that the attempt to comply with the dual exactions of the sliding scale has such a depletive effect upon the profits of the Company that all expenditure is thrown upon capital, a large part of which should be drawn from revenue, and the investment in the Company of surplus and undivided profits on which no interest is paid is stopped, and thus the most healthful financial process in Gas Administration is denied to those responsible for it.

Fourthly, the only section of the proprietorate who could benefit largely or continuously under the sliding scale are the original proprietors, and when their holdings have once been placed on the market, they are brought down to the level of ordinary investments, but with the invidious addition of a speculative character, owing to the uncertainties of the sliding scale in its operation."

The above conclusions are worthy of consideration as being those of a man having an intimate personal knowledge of the subject and who has made a special study of Gas Law and Gas Works Management.

It has been sought to cover briefly in this paper some of the more important questions arising in connection with the acceptance and interpretation of data; if it be found of practical value to any, the effort will more than have been repaid, and although the discussion has been confined to matters relating particularly to our profession, it is hoped that the plea for careful work and right thinking may be accepted in a wider sense and liberally interpreted to the advantage of all.

THE CHAIRMAN: We have but ten minutes before our agreed time of adjournment, which will preclude discussion of this excellent paper. The thanks of the association are due to Mr. Miller and Mr. Luqueer for their very interesting papers. The next on the programme is the Booster System at Rochester, by Mr. Frank Hellen.

A BOOSTER SYSTEM—ROCHESTER, N. Y.

About a year ago the pressure conditions in the southwestern section of Rochester were such as to call for immediate attention, 14/10ths being the maximum pressure in the territory bounded on the North by West Avenue and on the East by Caledonia Avenue. The 10 inch line which runs south on Caledonia showed a main line drop of 25/10ths from West Ave. to Plymouth Ave. a distance of 3600 feet. Pressure readings taken on the 16 inch line at the junction of West Ave. and Caledonia Ave. showed 4

inches, the drop in pressure from the works to this point being exceedingly low, due to the fact that the feeders thereto consisting of one 16 inch and two 12 inch mains were of ample capacity.

In this situation there were two remedies to choose from, one being the extension of our 16 inch pumping line in Clarissa Street, and under the bridge which spans the Genesee River at that point, and the installation of an exhauster at the works, which would pump the gas at a high pressure, involving an outlay of approximately $30,000. The alternative being the installation of a fan system so located as to enable us to pump from the West Avenue mains into those in Caledonia Avenue and Exchange Street, the estimated cost of such a system being $3,000.

As the congestion in the territory to be cared for was the result of rather a long period of years, and as there was nothing to indicate a recurrence of such conditions within a lesser period of time to come, it seemed to us that this $27,000. difference could be put to more fruitfulness than tieing it up in an exhauster scheme. Therefore, we chose the less expensive remedy, believing satisfactory results would follow its use, and in this we were not disappointed.

A blower house 13 ft. by 22 ft. built of tile was erected near the corner of West and Caledonia Avenue. In this we installed a 40 H. P. electric motor and a No. 10 Sturtevant fan, the inlet of which we connected with the 16 inch main on West Avenue, while the outlet was connected to 10 inch main on Caledonia Ave.

We planned to pump from the 16 inch main on West Avenue into the 10 inch main on Caledonia Avenue, thence through the 10 inch main on Troup Street East to Exchange Street, thence south through the 10 inch main on Exchange Street to Clarissa Street, thence west through the 8 inch main on Bartlett Street.

All small mains on the route of the new pumping lines were disconnected therefrom, and the services along the route

connected to the 10 inch mains were equipped with house governors.

A valve was placed on Exchange Street line just north of Troup Street to insure continuance in a southerly direction of the effect of the fan operation.

The small mains in Greig Street, also in Plymouth Ave. North of Clarissa Street are supplied from the new pumping line by means of valves. These valves are only a temporary expedient, and they will shortly be replaced by street regulators.

Between November 10, 1908, and March 1, 1909, the average duration of pumping was three hours nightly. The pressure carried on the outlet of fan ranged anywhere from 10 inches to 20 inches.

The maximum pressure obtained at Clarissa Street during pumping hours was eight inches, while throughout the territory where our low pressure troubles formerly existed we had no difficulty in maintaining a uniform pressure of 3 inches. The maximum hourly discharge in this territory was 70,000 ft.

In the immediate vicinity of the Clarissa Street line we had some difficulty on account of excessive pressure, but this has been wiped out by the installation of house governors.

The total cost of this installation including fan, motor, house governors, street connections and building was $3,200.

Interest, depreciation, and taxes 10%	$320.
Rent of ground used for building	120.
Cost of labor for pumping and incidentals	150.
	$590.

Interest, depreciation and taxes on installation of exhauster at works and extension of 16 inch pumping line would be $3,000. Thus we figured that we saved $2,140 the first year, taking as the estimated cost $30,000. In this you will notice

that I did not figure electric current, as this would be offset by pumping expense at works.

The Gas Engineer who studies his system of mains realizes that an investment in additional main and equipment for boosting service pressure is there for 8,760 hours a year, and will probably be brought into its maximum use for only 250 hours a year. If he can get through a year or two with a booster plant, he is much safer in then determining just what main equipment he needs to reinforce his pressure.

In Rochester we have been particularly pleased to think we did not continue the 16 inch high-pressure main into the Booster District, for since considering doing so, we have decided that we shall probably need a 3,000,000 foot holder, and if we should build one it now looks as though it would be an outlying holder. In this event our present 16 inch H. P. mains will be ample for ten years to come, and the investment that would have gone into the main, will be in a storage holder, which is a very desirable place to have it.

Briefly summing up we find,

First: Dollars and cents saved on installation.

Second: We are not working in excessive high-pressure. This means a decrease in leakage and maximum safety.

Third: The advantage of making an installation that requires a moderate investment.

Fourth: The large gas mains which were laid to the heart of the City in order to insure an adequate supply thereto at the time when gas was used almost exclusively at that point, and which have long since outlived the conditions which compelled their installation because of the encroachment of electricity in their particular field, and to which high-pressure lines would probably never be connected because no good purpose could thereby be served, are utilized by the Booster System as a source of supply, and are therefore again a necessary part of our main system, and their value is nearly if not quite as great as when originally laid.

While we do not wish to maintain that our satisfaction with the Booster System is to be regarded as final, we present the case in the hope that other members of the fraternity may be benefited by our experience. For those who need an outfit to relieve conditions similar to those we suffered from, and where the question of initial cost and subsequent operating cost is a serious one, we would recommend the Booster System.

THE CHAIRMAN: I do not intend to invite discussion on this paper, because our time has expired. We will now adjourn to meet in the main hall with the main body of the Institute.

(At this point both sections met as a general meeting and the President resumed the chair).

THE PRESIDENT: Is there any further discussion desired on this question? If not, I will ask for the report of the Committee on

NEXT PLACE OF MEETING.

MR. MCKAY: Mr. President, the committee considers favorably holding the next convention at Atlantic City, but requests a continuance, that it may confer with a like committee of the National Commercial Gas Association, with a view to holding the annual conventions of the two associations at the same place during the same week. The committee desires authority to present, at a later date, a final report to the Directors of the Institute.

WM. E. MCKAY,
J. D. SHATTUCK,
FRANK W. FRUEAUFF,
Committee.

MR. MCDONALD: I move that the report of the committee be concurred in.

The motion was seconded and carried.

THE PRESIDENT: In this connection I might say that the joint special committee of the Institute and the Commercial

Association, appointed to consider the matter of some form of consolidation, is not at this time ready to make a final report, though substantial progress is being made.

It can fairly be claimed that this meeting has demonstrated that sectional meetings can be carried on successfully. This was a necessary step to a desired end. The joint committee has every reason to believe that a meeting can be arranged for next October, at a common meeting place, at the same time, possibly in sectional form, but in such form as will be satisfactory to both bodies.

MR. MCDONALD: If it is in order I will carry out what I consider an instruction given to the Chairman by the meeting of the Commercial Section. That meeting has brought out the fact that a small assemblage of men, intensely interested in one subject, will bring out a fuller and more intimate discussion of that subject than will a much larger body of men of whom only a percentage are interested in it. The matter of dividing this Institute's meetings into sections so that distribution men will not have to listen to purification papers, and vice versa, has been before the directors for three years. They have hesitated to act upon it, because they did not definitely know the wishes of all the members of the Institute. The meeting down stairs, after discussing this matter, passed the following resolution:

"RESOLVED, That it is the sense of this meeting that the discussion of special topics on the part of those men who are especially interested in such topics is extremely desirable and profitable."

I report that resolution to the whole body for their dissent or approval, as they think best. The directors of the Institute will be governed or influenced by the expression of the opinion of the Institute at large.

MR. SEARLE: I move, Mr. President, that we ask the approval of the American Gas Institute as here assembled

by a rising vote. It seems so important that I take great pleasure in doing it.

The motion was seconded.

THE PRESIDENT: It has been moved and seconded that we have a rising vote as to whether or not, in the opinion of the gentlemen here assembled, the sectional meeting feature has proven a success at this time. Those who believe that it has will please rise. (The meeting rises). Those who believe otherwise will please rise. (No one arose). There seems to be but one opinion, that it has been demonstrated to be a success.

Is the Committee on Beal Medal ready to report. Mr. B. W. Perkins is chairman. (No response).

Next is the report of the Committee on the President's Address, Mr. E. C. Jones, Chairman.

MR. JONES: To the President and members of the American Gas Institute:

Your Committee appointed for the purpose of reviewing the address of the President report as follows:

We commend the address for its strength, breadth and fairness of its treatment of subjects connected with the welfare of the gas industry.

With reference to the generous contributions to the success of association work by representatives of the larger interests, we realize that this, of necessity, has been the case, and we hope that the invaluable work of these larger interests will continue unabated. We also hope that the other interests may emulate their example, and we strongly urge them to do so. We heartily endorse the recommendation that a committee be appointed to care for the interests of the Institute in its relation to commercialism, and that papers dealing with this important branch of our business be presented at each meeting. We also endorse the recommendation of the President, that it be the duty of the Public Relations Committee to secure for our program papers dealing with this very important branch of our work.

We believe that the day has come when we must look to our commercial departments for constant substantial increase in gas consumption.

Respectfully submitted,

E. C. Jones,
A. M. Barnes,
C. C. Simpson,

The President: There is due at this time the naming of the General Committees for the coming year. The following gentlemen have been appointed to serve:

Public Relations Committee,

C. H. Nettleton, New Haven, Chairman;
J. L. Richards, Boston;
W. F. Hart, Washington;
Donald McDonald, Louisville;
R. C. Dawes, Chicago;
J. T. Lynn, Detroit.

Technical Committee,

W. Cullen Morris, New York, Chairman;
A. H. Strecker, Newark;
T. R. Beal, New York;
W. H. Fulweiler, Philadelphia;
J. N. Morehead, Chicago;
G. E. Goodnow, Chicago.

That closes the business of the session.

Mr. Pratt: I feel that I have had enough to do with arranging for meetings like this to appreciate fully the work done by the various committees in making a success of the same. Probably there are a great many members here who have not had such experience, and therefore cannot fully appreciate the amount of work required in preparing for such a meeting. I always feel that I should like to take by the hand, and thank personally, any man who has assisted in any way in making these meetings a success. I therefore move Mr. President that a vote of thanks be extended to the Officers of this Association, to the Committee of Arrangements, and

to any gentleman who has had anything to do toward furthering the success of this meeting.

There were several seconds to the motion.

THE PRESIDENT: It has been moved and seconded that the thanks of the Institute be extended not only to the officers of the Institute and to the Committee of Arrangements but to everyone who has helped in any way towards the success of the meeting. As many as are in favor of that motion will please rise. (The meeting rose). Those opposed. It is a unanimous vote.

We have now at our disposal some 30 minutes, if any gentleman has any business that he would like to bring before the meeting.

MR. DEWEY: I agree that a vote of thanks should be extended to all of the people who have been instrumental in making a success of this Detroit meeting and I think we should extend our special thanks to the Engineers in charge of the work at the Livingstone Channel which we shall visit tomorrow and also to the Solvay Process Company, who are going to entertain us tomorrow. They have both gone to great expense, and are prepared to show us many interesting and instructive things. I therefore move that the thanks of the Institute be extended to the Engineers in charge of the work at the Livingstone Channel, and to the Solvay Process Company, for their invitations and the program that they have prepared for us tomorrow.

The motion was seconded.

THE PRESIDENT: It has been moved and seconded that the thanks of this body be extended to the Engineers of the Livingstone Channel and the Solvay Process Company for their kindness and the work they have done toward making the entertainment portion of this meeting a success. As many as are in favor of that motion will signify it by rising. (The meeting rose). Those opposed. It is a unanimous vote.

Is there any further business? If not, a motion to adjourn is in order.

The meeting then adjourned at 4:30 P. M.

APPENDIX TO PROCEEDINGS

OF THE

AMERICAN GAS INSTITUTE

1909

In Memoriam.

FREDERICK R. PERSONS
Toledo, Ohio
Died August 1, 1909

CHARLES S. KNIGHT
Fort Wayne, Indiana
Died August 14, 1909

O. P. MOON
Cleveland, Ohio
Died October 26, 1908

C. H. JACOBS
Detroit, Mich.
Died March 15, 1909

DAVID H. GILDERSLEEVE
West New Brighton, N. Y.
Died July 30, 1909

FREDERICK RILEY PERSONS

BORN, 1856. DIED, 1909.

Frederick Riley Persons was born in East Aurora, New York, His early business experience was in the Pennsylvania oil fields. About 1878 he became identified with the gas business and occupied responsible positions with the gas companies at Akron and Elgria, Ohio; and Omaha, Nebraska. From 1884 to 1891 he represented Harris, Griffin & Company in Chicago. For the next six years he was connected with the Standard Oil Company. For the past 12 years he represented the Maryland Meter Company, with headquarters at Toledo, Ohio.

He became a member of the American Gas Light Association in 1888. He was also a member of the Ohio, Western and Michigan Gas Associations, and came into the American Gas Institute as a charter member in 1906. He was a thirty-second degree Mason and belonged to other fraternal organizations.

Mr. Persons had a wide acquaintance and many devoted friends among gas men, and will be especially missed at association meetings. He was always untiring in his efforts to make such meetings a success, particularly as to the social side.

CHARLES S. KNIGHT.

FORT WAYNE, INDIANA.

Mr. Knight was for many years identified with the gas and electric lighting business in Fort Wayne, Ind. He joined the Western Gas Association in 1884, the American Gas Light Association in 1890, and came into the American Gas Institute as a charter member in 1906.

O. P. MOON.

CLEVELAND, OHIO.

Mr. Moon was Manager of the Standard Lighting Company. He joined the Ohio Gas Association in 1898, and came into the American Gas Institute as a charter associate member in 1906.

C. H. JACOBS.

DETROIT, MICHIGAN.

Mr. Jacobs at the time of his death was Secretary, Treasurer and General Superintendent of the Detroit Meter Company. He joined the American Gas Light Association in 1897 and was also a member of the Michigan Gas Association, He came into the American Gas Institute as a charter associate member in 1906.

DAVID H. GILDERSLEEVE.

WEST NEW BRIGHTON, NEW YORK.

At the time of his death Mr. Gildersleeve was Sales Manager for the C. W. Hunt Company. He was a graduate of Stevens Institute. He joined the American Gas Light Association in 1905, and came into the American Gas Institute as a charter associate member in 1906.

APPENDIX.

Bureau of Information.

Questions Answered During the Year.

Note: Neither the Board of Directors of the Institute nor the Institute as a body make themselves in any way responsible for the statement of fact or expressions of view given out by the Bureau of Information.

Question No. 10.

Can the Bureau of Information inform me if there is any particular kind of anthracite broken coal particularly adapted for water gas manufacture? If so, from what region or vein is this coal mined?

Question No. 25.

What rule and method should be followed in designing condensers to remove condensation resulting from compression of gases?

Question No. 29.

Does very rapid condensation tend to reduce the permanent illuminating power of coal gas? Experience shows that the illuminating power of coal gas when condensed very slowly is considerably higher at the works that when the gas is condensed very rapidly. In the latter case, however, there is apparently much greater loss of illuminating power in distribution, especially in cold weather due to the condensation of the heavier hydrocarbons. It is evident that it is possible to install gas-condensing apparatus costing less than half what the approved apparatus costs but in which the work can be done very rapidly and also very efficiently so far as the use of cooling water is concerned. Would the use of such apparatus result in an appreciable loss of illuminating power at the consumers' burners as compared with the use of the present approved types of apparatus?

Question No. 36.

What is the mean spherical candle-power of the standard candle? Is there any objection to taking readings of candle-power at the angles used for determining mean spherical candle-power instead of every 10 or 15 degrees as is customary at present. It would greatly simplify the present method of determining M. S. C. P.

Question No. 37.

Will the Bureau of Information furnish me with the analysis of the fire-brick that is considered of good quality for checker brick work in carburetter and superheater?

Question No. 38.

We have a greenhouse man here who is very anxious to heat his greenhouse with 23 c.p. water gas, using it in a Boynton Furnace. We are advising against it but he says he will not object to paying up to $800.00 for the season. The greenhouse is exceedingly well built mostly of glass with 5500 feet of radiation which keeps it amply warm with soft coal.

The furnace is No. 191 as shown on page 40 of their 1905 catalogue.

We would expect to take him on at about an 80 cent rate. What is your opinion, should we come anywhere near $800.00 for the season? Are there any installations in use where artificial gas is used in hot water and steam residence work?

Question No. 40.

Does any apparatus exist by which ordinary illuminating gas can be used in connection with "Prest-O-Lite" tanks for furnishing illumination for automobiles?

Question No. 41.

What is the difference in the number of candles of light obtainable from a gallon of kerosene oil used in coal oil lamps, for illuminating purposes, and 100 cubic feet of 18 c.p. gas?

Question No. 42.

Is it a good practice for a small plant to test meters by taking a new meter just from the factory inserting it just after the meter of same size to be tested and allowing consumer to use two to three thousand feet with the two meters in series, keeping an accurate record of the readings at beginning and end of test period?

Question No. 43.

Should a vent pipe be used on all small water heaters such as the Lawson No. 1, in all cases?

This heater is used to heat range boilers with the pressure on coil in heater and tank alike.

Question No. 44.

Do you know of any good formulas for manufacturing a paint out of pure coal tar for iron or steel? Also can you give any information as to whether a tar paint is injurious for the above metals?

Will you also designate whether any of the components of the paint formulas furnished are intended to neutralize any acids which may be in the paint?

Question No. 45.

a What is the ultimate analysis of the gas oils used in the different parts of the country?

b What is the percentage of the paraffin and benzene series compounds in the gas oils used in this country?

Question No. 46.

A large number of prepayment meters after being installed a few months run short, that is, the money collected from them does not equal the gas consumed. On examination the meter shows no signs of having been tampered with, and a test proves them to be correct. In what manner can this matter be explained?

Question No. 47.

Can you furnish me with information as to the results under ordinary working conditions, of the yield of creosote oils per gallon of water gas tar and also per gallon of coal gas tar?

Question No. 48.

What are the comparative merits, in the case of large Companies, of making meter repairs under a "piece work schedule" as compared with strictly "day work?"

Question No. 49.

In coal gas manufacture, would the admission of one (1) per cent. of air at the mouth-pieces oxidize some of the heavier hydrocarbon vapors and result in an appreciable increase in the vapor tension of the remaining hydrocarbon vapors in the gas?

Question No. 50.

What relation should the capacity of the gas bag or tank, usually placed before the inlet of the gas engine, bear to the gas consumption per minute of the gas engine, in order to prevent any fluctuation in the gas mains from which the service to the gas engine is taken, without the use of any other governing device?

Question No. 51.

In the larger cities, how many district shops should be utilized in order to realize the most economical distribution costs? Assume the condition as to the number of consumers per unit of area, also the size of the city and local characteristics as to growth, etc. The answer should also state the advisability of operating any of the other departments in connection with the Distribution Department at these district shops. Also, is it advisable to separate the costs of operation for each shop, at the same time cutting out a large number of special or detailed accounts, depending entirely on the comparison costs of the shops for a knowledge of the work done?

Question No. 52.

What Companies are using automobile trucks in any part of their distribution work, and do they find same to be an economical investment?

Question No. 53.

What is the best method employed for taking candle-power of illuminating gas with a bar photometer? Which is preferable, a star disc or the circular grease spot?

Question No. 54.

In the matter of gas lamps which are owned by gas companies and are rented to consumers, are there any cases where the rental system has not proven satisfactory, or where another system has proven more satisfactory?

Question No. 55.

Please give a list of the best books, or other sources of information, on American practice in gas distribution.

Question No. 56.

Do Gas Companies generally correct the gas made, that is, the gas metered by Station Meters at manufacturing stations, for drip water and oil collected from the distributing mains throughout the city?

Also, is the gas made corrected for barometric pressure, as well as temperature, and to what pressures and temperatures?

ANSWERS BY THE BUREAU AND ANSWERS-AT-LARGE TO THE FOREGOING QUESTIONS.

Question No. 10.

Answer-at-Large by W. H. Fulweiler Philadelphia, Pa.

Reply:—Baldly, the answer is "No."

We believe that the method of buying coal on the analysis basis is the only proper one, and that coals may come from widely differing fields, yet if they present certain favorable

characteristics, taken in connection with their delivered cost, they may be considered as equally good fuels for water gas manufacture.

In other words, we believe that the coal that yields the maximum useful amount of carbon, with a favorable ash composition, at a minimum cost per unit of carbon delivered is the most suitable fuel. Consequently, our following reply relates to the manner in which the constituents of a coal affect its value.

The constituents and properties of an anthracite coal that are factors in its employment as a fuel for the manufacture of carburetted water gas are in the order of their importance.

1. The percentage of fixed and volatile carbon.
2. The percentage and composition of the ash.
3. The size and behavior of the coal on heating.
4. The percentage of moisture.
5. The percentage of sulphur.

Since we use our fuel as a source of carbon its value must depend primarily, other things being equal, upon the percentage of combustible carbon carried by the coal in question.

Combustible carbon is present as volatile combustible and fixed carbon. The ratio between the fixed carbon and the volatile combustible is used as a basis in the classification of fuels. Hard, dry anthracites have a ratio of from 28-13, with an average of about 21, and we believe that a good generator fuel should belong to this class, thus having not more than 7 per cent. volatile combustible when calculated on an ash and water free basis.

With this limitation, we may in general consider that the value of a coal is proportional to the percentage of combustible carried. Even though volatile combustible may be liable to partial loss in blasting, nevertheless because its calorific power is somewhat greater than that of fixed carbon we feel that within the above limits (7 per cent.) it may be considered as the equivalent of the same weight of fixed carbon.

The presence of ash is a detriment in two ways,—it replaces combustible carbon, and its presence necessitates more or less frequent cessation of operation for its removal, thus causing a loss of capacity, labor, combustion during cleaning, and a direct loss of carbon removed and lost during this operation. Although the degree of care taken in operation will greatly influence results, we believe, from calculations and experience, that in practice each 1 per cent. of ash will probably result in wastes and costs that are equivalent to 2 per cent. of carbon in the fuel. Thus, a coal containing 10 per cent. of ash would only deliver the equivalent of 80 per cent. of the carbon compared to a coal having no ash.

Commercial anthracites all contain some ash, running from 4.5-20. Up to 10 per cent. we believe that the value is depreciated in the above ratio of 2-1, and that a first-class fuel should not contain over 10 per cent. ash, but coals containing 12 per cent., or even somewhat higher can be handled satisfactorily.

The composition of the ash is quite as important as its volume in influencing the value of the coal for generator purposes, although but little attention is generally paid to this point.

We believe that the most satisfactory operation is secured with an ash having a high fusing point. A number of formulas have been proposed to determine this from the chemical composition, but they all fail to give satisfactory results when applied to ashes having percentages of iron, magnesia and alkalies totaling over 10 per cent.

In general, we believe that we desire an ash having high and nearly equal proportions of silica and alumina, with very little, if any, calcium, and the lowest possible percentages of iron, magnesia and alkalies.

Percentages of silica or alumina below 30 per cent., iron above 15 per cent., calcium above 10 per cent., alkalies or magnesium above 3 per cent., should generally be looked upon with suspicion.

As iron is the usual flux that reduces the fusing point of the ash, the presence or absence of the reddish color it imparts may frequently give the clue to its character. Generally, the white or grey ashes are the more infusible.

The following analyses of good, fair and bad ash may be of interest.

	Good	Fair	Bad
Silica—Sio_2	54.67	46.23	46.40
Alumina—Al_2O_3	41.95	31.93	16.45
Iron Oxide—FeO	trace	14.54	18.15
Lime—CaO	1.82	5.04	11.80
Magnesia—MgO	1.46	2.26	4.63

The composition of the coal is somewhat affected by the size, the smaller sizes running considerably higher in ash and correspondingly lower in fixed carbon.

The coal should not decrepitate or break up when heated, as this clogs the fuel bed and reduces the capacity. While this is quite noticeable in the Welsh anthracite, it is only occasionally observed in American varieties.

The percentage of moisture is a direct loss, both as displacing combustible carbon and owing to the fact that this water must be evaporated and the vapor heated to the temperature of the superheater top. Each 1 per cent. of moisture will require about .11 per cent. of carbon to evaporate and heat it so that 1 per cent. of moisture reduces the value of the coal an equivalent of 1.11 per cent. of combustible carbon.

The percentage of sulphur is not so important in generator fuel as it is in gas coal, as only about one-half of the total sulphur is volatile, and about one-half of this goes into the illuminating gas. Sulphur usually varies from .4 per cent. to 1.5 per cent., but as high as 3.0 per cent. has been found. In a first-class coal it should not run of over 1.1 per cent.

Having thus briefly reviewed the different constituents as they affect the suitability of a coal for generator fuel, it may

be of interest to very briefly consider the sources of anthracite supply, and the general characteristic of these coals.

In the United States anthracite coal occurs in a number of localities other than Pennsylvania, average analyses of these coals being as follows:—

	Rhode Island	Massachusetts	Arkansas	Colorado	New Mexico
Moisture	8.36	2.05	1.06	.72	2.90
Volatiles	6.09	4.99	8.41	7.62	3.18
Fixed Carbon ..	73.23	76.96	75.43	87.51	88.91
Ash	11.68	15.44	11.74	4.51	5.21
Sulphur	.64	.56	3.34	.....	.....

Similar information concerning Pennsylvania coals is given in the following table (taken from the Geological Survey) which gives the characteristics of the different veins as they occur in the five groups of the three general fields, viz., the Wyoming, which includes the Northern and Loyalsock; the Lehigh, including the East Middle and part of the Southern, and the Schuylkill, which includes the West Middle and the remainder of the Southern field. It will be noted that even a given bed of coal will vary in its analysis as it appears in different fields.

Field	Group	Bed	Moist	Vol.	Fixed carbon
Wyoming	Northern	Mammoth	3.42	4.38	83.27
	Loyalsock	"B"	1.30	8.10	83.34
	E. Middle	Wharton	3.71	3.08	86.40
Lehigh		Mammoth	4.12	3.08	86.39
	Southern	Primrose	3.01	4.13	87.98
	W. Middle	Primrose	3.54	3.72	81.59
		Mammoth	3.16	3.72	81.14
Schuylkill		Black Mt.	3.04	3.95	82.66
		Seven Foot	3.41	3.99	80.81
	Southern	Mammoth	3.09	4.88	83.81

Field	Group	Bed	Ash	Sulphur	Ratio fixed carb. vol. comb.
Wyoming	Northern	Mommoth	8.20	.73	19.0
	Loyalstock	"B"	6.23	1.03	10.29
	E. Middle	Wharton	6.22	.59	28.07
Lehigh		Mammoth	5.92	.50	27.99
	Southern	Primrose	4.38	.51	21.32
	W. Middle	Primrose	10.65	.50	21.93
		Mammoth	11.08	.90	21.83
Schuylkill		Black Mt.	9.89	.46	20.93
		Seven Foot	11.23	.51	20.32
	Southern	Mammoth	8.18	.64	19.62

The above analyses were made some years ago. It is probable that the analysis of the average coals to-day are not so good.

Question No. 25.

Answer by the Bureau of Information.

This is a question on which present information is not sufficient to allow a thoroughly definite answer to be made. As far as we were able to ascertain, no work has been done on determining the results of condensing high pressure gas to ground temperature at the point where it is compressed. The practice has been to have this condensation take place in the pipe line, one advantage of which is, that some of the oils the condensation dropped on one day at a high pressure temperature, will be picked up at a later day at a different temperature. This may not be considered an advantage on account of its irregularity and certain loss of some of the oils. If the gas is condensed within the works, the oils can then be retained, and a corresponding value of their oil can be introduced at the point of delivery for re-enrichment. Certain general assumptions of the problem can be presented however. The amount of condensing surface necessary to reduce the temperature of the gas can be mechanically deter-

mined by figuring the number of heat units to be abstracted, and there is not much trouble therefore in bringing the temperature of the gas down to a point to condense the moisture. Given the maximum compression, and the lowest ground temperature, the sizes of the necessary condensers can be readily determined.

The real trouble, however, is to remove the condensation. In low pressure the gas flows at a slow velocity, and this moisture readily settles in the bottom of vessels, and is drawn off. In the case of high pressure gas, the high velocity of the gas carries this condensation along, sometimes as a fog, and again in frictional contact with the sides of the mains. The condensing surface designed when a high pressure system is first installed, and the flow of the gas slow, may be adequate, but as the business increases, and the velocity through the main increases, the system becomes inadequate. High velocity may not be a disadvantage under certain conditions, as through it the removal of all condensate ready to come down can be affected like the removal of water from steam. It would appear therefore, that high pressure condensers should be arranged to abruptly change the course of gas at frequent intervals, and at those points where condensate will be shaken out, provision should be made for the immediate removal of the condensate, as is done in the Cochrane steam separator.

There is a difference of opinion as to the velocity question. Some think that the condensing chamber must be large enough so that the flow of gas through it is comparatively slow.

Recent experiments have indicated that it is possible that some oil condensate may be precipitated by the water condensate and that could this dragging down of the oil by the water be prevented, the total oil condensate would be much reduced.

This is wholly a matter of guess work at present as there is no conclusive information as to what the total oil condensate should be under various conditions. But it would seem de-

sirable for the present at least, that the water condensate be drained off quickly as formed.

A possible type of condenser that suggests itself is the type used in ammonia practice, the high pressure gas to be sent through a series of tubes, surrounded by cooling water. Quick and frequent reversal of flow could easily be arranged in such a condenser.

Up to the present time, it has been thought that high pressure pipe lines need not be laid as deep as there was so little danger of stoppage from frost. This ignored, however, the danger of condensing the oils, and it is now known that shallow pipe lines for high pressure tend to produce a heavy deposit of hydrocarbon oils just as do shallow low pressure lines.

The low pressure that may be experienced in such pipe lines when the ground is thawing, and the results therefrom, may be found set forth in the present paper on this subject before the Illinois Gas Association, indicating the low limit which a works condenser would have to meet, if no after precipitation was to be expected in such a pipe line.

This whole question is entirely in its infancy, and investigations, especially on the question of re-enrichment, and experiments along the lines of works condensers would be very desirable. Reference is made to the paper above before the Illinois Gas Association which is the first paper of investigation before any of our associations on this general subject.

Question No. 29.

Answer by the Bureau of Information.

The question as stated partially answers itself. In other words, it premises that rapid condensation itself reduces the initial power of coal gas. The question, therefore, resolves itself into this form.

"Is there an appreciable loss in the illuminants in distribution especially in cold weather due to the condensation of the

heavier hydrocarbons in the coal gas where the gas has been condensed very slowly at the works and to a higher minimum temperature than that to which it is subjected in the distribution system?

At Station A plant in Detroit, where the test was conducted, we had the usual type of condensing apparatus employed in a coal gas plant. The primary condensers reduced the temperature of the gas at the inlet of the exhauster to 120° F., the secondary condensers reduced the temperature of the gas at the rotary scrubber to about 70°. The introduction of steam at the outlet of the rotary scrubber raised the temperature of the gas at the inlet to the purifiers to approximately 100°. For purposes of testing two small holders were installed, one taking an average sample of the gas at the inlet to the meter, and the other taking an average sample of the gas at the inlet to the meter after it had passed through a long line of small pipe exposed to the atmosphere. Eighty tests were taken, using Carpenter's Metropolitan No. 2 Argand burner for candle-power tests, and Junker's calorimeter for determining the heat units, with the following results:—

Holder test	Candle-power	B. T. U.'s
Unchilled gas	18.48	636.8
Chilled gas	18.01	632.1
Drop	.47	4.7

The average atmospheric temperature during test was 29° F. A series of line tests were run with the following results:—

	Candle-power	B. T. U.'s
Unchilled gas	18.87	.....
Chilled gas	18.62	.....
Drop	.25	.....

The average atmospheric temperature during the tests was 27° F.

From this it would appear that under the conditions named, the illuminants were pretty well fixed.

In addition to the official answer of the Bureau of Information to question No. 29, the Bureau suggests perusal of the subject marked "Condensation," as given on page 1015 of Vol. III of the "Proceedings of the American Gas Institute for 1908."

Question No. 36.

Answer by the Bureau of Information.

In regard to this question, the Bureau of Information wishes to make plain a few of the difficulties involved in answering same.

In the first place it is at once evident that no one would think of using the expensive standard candle for purposes of illumination. Yet when asked for mean spherical candle-power we usually have in mind some common form of illuminant whose polar curve of illumination we wish to know, in order to find its distribution of light in various directions, such as an electric arc, an inverted naked mantle, or any of the infinite variety of combination of illuminant and shade or reflector.

When we speak of the standard candle, we have in mind a standard or a unit of light, and there is a prescribed way in which that unit is to be used; namely, its horizontal rays are to be taken as furnishing a unit of light when the candle is burning in a proper way and at the correct weight of sperm consumption. To determine the polar curve of a standard sperm candle, and to compute from that the mean spherical candle-power, would be a task indeed; that is considering a determination which would stand in the technical world.

There has been an international argument over the value of the horizontal ray alone for the past two decades; how much more then are the obstacles to be overcome in securing a correct value for each of the twelve positions necessary to be observed in determining the polar curve?

In addition to this, there are certain arguments from a

point of policy which should render us very careful in our statements on this subject.

Without going too deeply into the various pros and cons of this question, the Bureau wishes to state that one of its members, Mr. C. O. Bond, Chief Photometrist of the United Gas Improvement Company, Philadelphia, kindly volunteered to get up an answer to this question, and while this answer is to be considered the official answer of the Bureau of Information, as Mr. Bond is a member of the Bureau, yet we wish to ascribe due credit to him for his work.

The answer as compiled by Mr. Bond is as follows:

"*a*" In the London Journal of Gas Lighting, under date of February 6, 1894, page 239, an article was found in which were shown various readings from which the mean spherical candle-power of a standard candle was computed. These values were determined by means of a 5" revolving reflector used at a 45° angle and the experiment was made at the Central Station of the City and Guilds of London, under the care of Prof. Ayrton.

The distribution curve determined by him ran from 69° above the horizontal, to 75° below the horizontal, and he ascribed a value to the candle of 1.06 in a horizontal direction.

As the candle assumed in the above question is a standard candle, all the values given have been divided by 1.06, in order to reduce his distribution curve to that which would be given by a standard candle. Prof. Ayrton said that he found the mean spherical candle-power to be .94, and this divided by 1.06 would give .88 as his determination of the mean spherical candle-power of a standard candle.

Upon plotting a polar curve from his figures, however, and comparing it with other polar curves determined for a standard candle by Mr. Bond, using a Weber photometer, he finds all curves to be in fair agreement, and the mean spherical candle-power instead of working out to a value of .88, proves to have a value of 1.01, as shown on the accompanying chart, when the horizontal candle-power is taken as unity. At the

two points in the upper hemisphere, namely, at about 105° and 140°, the curve shows abnormal values in candle-power. This high value of the candle at these two points seems to be due to a reflector effect from the melted sperm in the cup of the candle. From the figures given in Prof. Ayrton's experiment, the M. S. C. P. was not properly determined.

This polar curve of the standard candle is not put forward as being an accurate one but rather serves to show the general shape of such a curve. It can be seen that to make an accurate determination a great number of readings would be necessary, to be taken while the candle was burning at its normal consumption, and having the candle rotated through all horizontal angles.

"*b*" Answering the second part of the question, the distribution curve has been derived first in the usual method, and second, by the method suggested in Question No. 36.

While there are slight differences in the two curves, there would appear to be no reason why the method suggested in the question could not be used, if care were taken to explore those angles near the zenith and nadir, to ascertain if any irregularities were present in the curve at those angles.

The two figures on the chart serve to illustrate the question asked. Let us consider the upper figure in which is shown the determination of a distribution curve and the laying out of a Rousseau curve from which may be determined the mean spherical candle-power.

The semi-circle A C B is drawn with its center at O: concentric lines at equal intervals show in this case 10ths of candle-power such as 2, 4, 6, 8. At zero degrees, which is directly beneath the candle, it gives no light: at 15° from the vertical it gives .4 of a candle; at 30°, .85; and so on to 180° where it gives about .98 of a candle.

When we speak of mean spherical candle-power we imagine our light source to be in the center of a sphere and the result we desire is the average or mean illumination on the entire inner surface of that sphere.

The curve A C O merely shows the distribution of the light in a vertical plane, and it is clear that the zone illuminated between 90° and 105° is a considerably greater area than the zone illuminated between 165° and 180°. In order to average the illumination on the entire inner surface of sphere, it is necessary therefore, to give an equal weight to equal areas, and this is accomplished by the laying off of the Rousseau diagram, shown on the right, bounded by lines D H J E, in which D E is the base line. The distance from D to H shows the candle-power in the direction O A, or at 180°. The next line below D H, and parallel to it, intersecting the curve below H shows candle-power in the direction of 165 degrees. As the zones approach the horizontal, therefore, they are increased in width corresponding to their area.

We will now drop to the second figure in the diagram in which this same area is the enclosure of D′ H′ J′ E′. In this case, the horizontal lines are drawn at equal intervals in order to give a proper summation of the area included by D′ H′ J′ E′. This area in the second figure is divided into 10 equal divisions laid off upon the base line D′ E′ and the center of each division is indicated by a dotted line. Now, if these dotted lines are carried to the left until they intersect the semi-cirle, they will intersect it at approximately the following angles: 154°, 135°, 120°, 107°, 96°, 84°, 72°, 60°, 45°, and 25°. In substance then, the second portion of Question No. 36 is: Would not the distribution curve have been as accurately determined by taking readings at the different angles just mentioned, as it was by determining it at regular intervals of 15°, as shown in the upper figure?

If the curve is fairly regular there seems to be no doubt but that this second method would serve equally well. Most light sources, however, are supported either from above or below, and with some light sources where reflectors are used, as in deck lighting of show windows, there would be an enormous elongation of the curve at zero degrees, in which

case the number of determinations between zero and 25° would have obviously to be much increased.

The Questioner does not state the source of light to which he would like this question applied. In all bare light sources a great deal more value attaches, as a rule, to the horizontal rays than to others; both because they are valuable from the standpoint of light distribution, and also because they represent the zones of maximum area, and the method suggested by Question No. 36 would appear to take good care of these horizontal intensities. In such a case the arithmetical average of the ten readings suggested above, determines at once the mean spherical candle-power of the light source, without the necessity of further plotting.

This subject has been quite thoroughly discussed in Vol. 1, Page 715 of the Illuminating Engineer on The Measurement of Mean Spherical Candle-power, and in the March, 1908. issue of the same periodical, Mr. Norman Macbeth gives a method of determining the mean spherical candle-power direct from the distribution curve by means of a celluloid semi-circle, properly graduated, through which the candle-powers, at the various appropriate angles, may be read off directly.

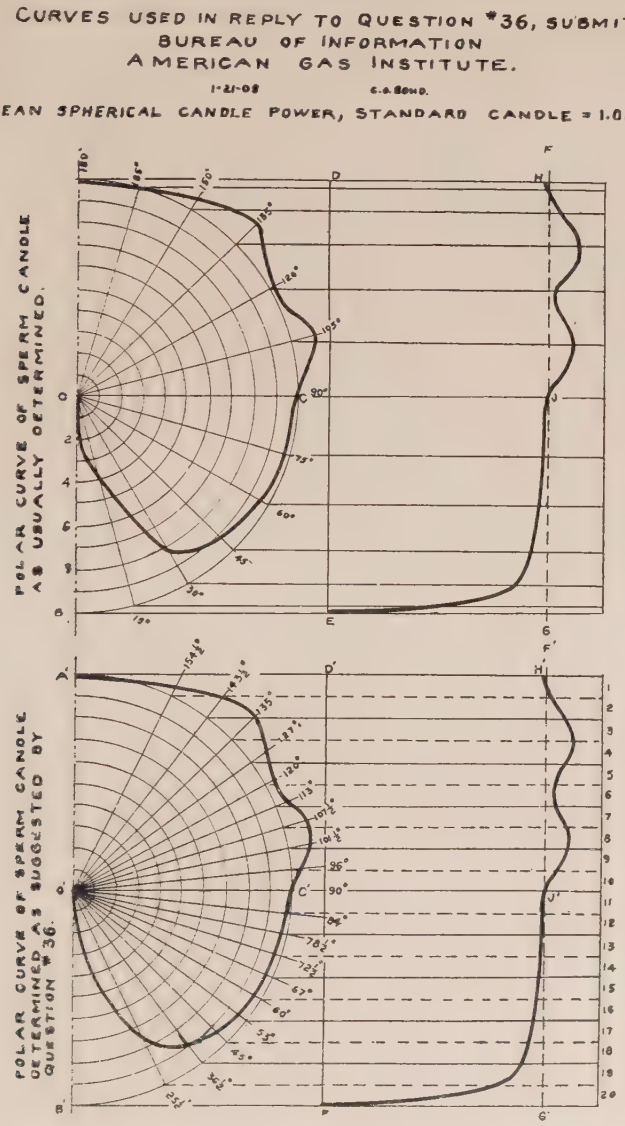
In Mr. Bond's discussion of the second figure on the chart, he has used only 10 equal intervals for the summation of the mean spherical candle-power in order to illustrate his point. It is probably a better practice to use at least 10 in the upper and 10 in the lower hemisphere, as better accuracy would result. In any case, before this second method is put into practice, the peculiarities of the distribution curve of that type of light source to which it is to be applied, should be well studied out.

Answer-at-Large,

By Mr. H. Thurston Owens, Consulting Engineer, 13 Park Row, New York.

With reference to the question regarding determination of Mean Spherical Candle-power would state that, if candle-

power readings are taken at regular intervals, as has been

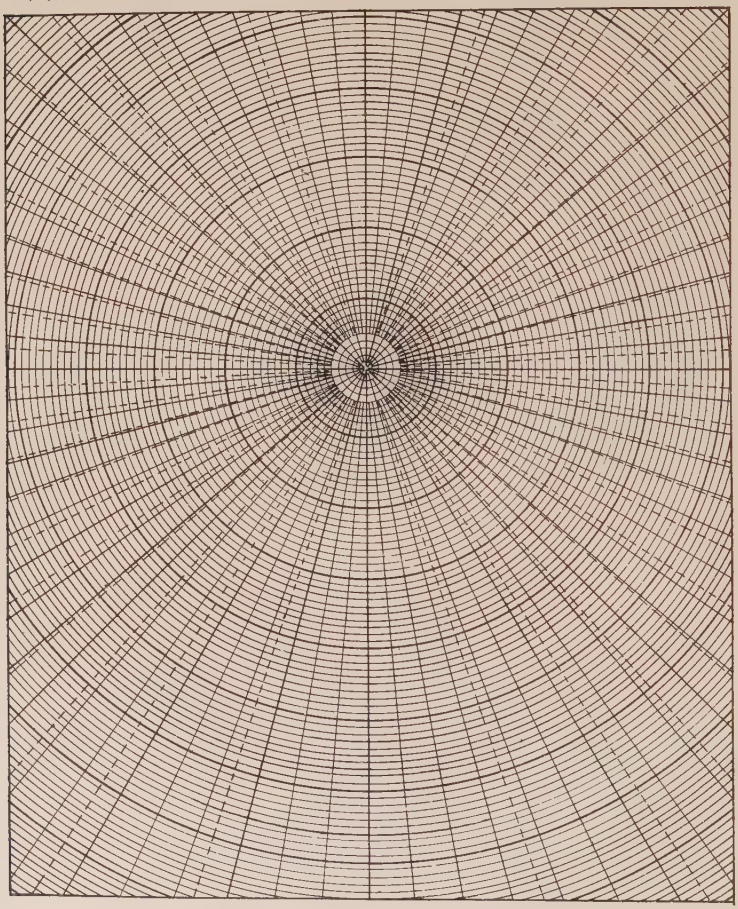

CURVES USED IN REPLY TO QUESTION #36, SUBMITTED TO
BUREAU OF INFORMATION
AMERICAN GAS INSTITUTE.
1-21-08
C.A.BOND.
MEAN SPHERICAL CANDLE POWER, STANDARD CANDLE = 1.01
POLAR CURVE OF SPERM CANDLE AS USUALLY DETERMINED.
POLAR CURVE OF SPERM CANDLE DETERMINED AS SUGGESTED BY QUESTION #36.

usually the case, and the results plotted on polar diagram

paper on which the angles referred to in the question are given, it is a simple matter to calculate the M. S. C. P.

Submitted herewith is a sample of the polar diagram referred to in the above.

POLAR DIAGRAM FOR DETERMINING M.S.C.P. AS IN QUESTION No. 36.



QUESTION No. 37.

ANSWER BY THE BUREAU OF INFORMATION.

In endeavoring to compile an answer to this question, the

Bureau of Information naturally ran into considerable difficulty. In general, this question appears to be an impractical one. The mere statement of a proportion of silica and alumina combined in a brick to produce the best article for a particular purpose may mean very little, that is, the condition of these two materials before they are put into the brick, the method of combining them, the slight percentage of various impurities, and numerous other conditions, really control the quality of the brick. The Bureau is under the impression that information on these essential points is not general. If, however, there are concerns in this country who know a great deal about this subject, it can be readily seen that such information would not be apt to be given out.

In view of these general considerations, the Bureau feels that it is not practical to give any answer to this question which would be valuable to the gas fraternity at large. However, certain features of this problem may be stated with propriety, and certain leading lines of thought may be brought forth which will assist any one studying the subject under consideration.

The following are some analyses of some representative American and European fire clays:—

	1	2	3	4	5	6	7	8	9
Combined Silica	.....	39.94	40.33	46.90	50.15	50.45	52.52	65.10	63.00
Alumina	.72	36.30	35.84	35.90	35.60	35.90	31.84	22.22	23.57
Water	.35	14.52	13.00	12.80	13.61	12.76	11.68	7.10	6.45
Alkalies	.14	.42	.66	.44	.07	..,..	.59	.18	2.69
Lime	.22	.19	.08	.....	.11	.13	.50	.14	.44
Magnesia	.....	.19	.38	.....	.16	.02	.19	.18	.89
Iron	.18	.46	.90	1.10	.83	1.50	.67	1.92	1.87
Free Silica	98.31	4.90	5.15	.....	.....	.....	.....	.....	.....
Moisture	.....	3.26	.....	.....	.....	.....	.....	2.18	.....
Titanium	.....	.....	.....	1.30	.....	.....	1.68	.....	1.10
Sulphur Trioxide	.....	.....	.....	.....	.14	.....	.....	.....	.....
Organic Matter	.....	.....	.....	.....	.....	.....	.....	.58	.....
	99.92	99.18	99.24	98.44	100.67	100.75	99.67	99.18	100.01

No. 1—Dinas Clay, England.
2—Saaran Clay, Germany.
3—Zettlitz Clay, Bohemia.
4—Woodbridge Clay, New Jersey.
5—Clearfield Co. Clay, Penna.
6—Mt. Savage Clay, Maryland.
7—Mineral Point Clay, Ohio.
8—Stourbridge Clay, Germany.
9—Mecca Clay, Indiana.

The foregoing are analyses of *fire clays,* and not of *fire brick* itself, and the Bureau wishes to direct attention to this fact.

In the choice of fire brick, the analysis, while it should be considered to a certain extent, is not the only quality of brick to be considered for this purpose. Checker brick should be of chemical composition to withstand the maximum heat, which it is to be subjected to, and should be capable of withstanding the rapid cooling and heating of the carburetter. Two bricks might be of exactly the same chemical composition and differ so widely in physical characteristics that one might be suitable and the other not. Since these brick will be attacked in direct proportion to their porosity and low heat at which they have been burned, it follows that a brick for checker work should be dense, or in other words, made up of fine grog and fire clay and be burned at a maximum temperature equal to the temperature probable in a carburetter and superheater.

Bricks containing quartz, or grog, of a different factor of expansion from that of a clay used as a mastic should be avoided, for rapid heating and cooling will cause cracking.

It should be noted that the Bureau of Information wishes to caution any one from buying fire brick by chemical analysis or by laboratory tests, as it has been found that laboratory tests are not very satisfactory in giving a line on just what occurs to a brick in actual use. In other words, it is apparently very difficult to secure parallel conditions in laboratory practice and generator house practice.

In addition to the foregoing, the Bureau would simply make the following additional general remarks.

It would probably be safe to say that a brick that would stand the severe service required in the regenerator of an open-hearth furnace would be peculiarly adapted for use in a carburetter or superheater, where the changes in temperature are not as great as in the former case. It is also stated to the Bureau that it is getting to be a common practice in open-hearth furnaces to use silica brick in that part of the checker work closest the furnace, and clay brick further from the furnace where the temperatures are lower. Silica brick would probably heat more quickly and give off heat more quickly than clay brick. There would, however, be a greater tendency for them to spall off if made with a lime bond. It is questionable, however, whether the temperatures in a carburetter or superheater are high enough to make it desirable to use silica brick.

There are a number of matters which require determination in connection with fire brick, in addition to the suggestions contained in the foregoing, and in addition to the analyses, namely, the specific gravity, conductivity, expansion and contraction, and different materials, etc.

The following suggestion comes from one of the members of the Bureau of Information, and relates to some experiments conducted by the United Gas Improvement Company, in connection with this subject.

"One of the chief qualities demanded in checker brick is the ability to endure without cracking the alternate heatings and coolings experienced in the carburetter and superheater; of course, the carburetter is the most trying place, the temperature fluctuations in the superheater being less. By means of the 'dipping' test described below, we have tested a very large number of sample bricks made from various processes. These tests have revealed an exceedingly great difference in the abilities of these samples to resist the fore-

going heating and cooling. The bricks giving by far the best average results have been those which, while compact and heavy, are composed very largely of quite coarse, angular clay particles, and flint clay used as a binder. The sample No. 5 quoted in the first part of this answer, however, if freed from its water, would give an analysis resembling the analysis of these bricks which we have found best; also we judge sample No. 21, mentioned in a very complete paper by Mr. R. F. Weber before the 1904 meeting of the American Institute of Mining Engineers, to be about the same as the brick which we have found best. As stated in the foregoing, however, it is probable that analysis is only a fair general guide to the excellence of a brick, very much depending upon the size of the particles of which it is composed.

The dipping tests above alluded to are made by successively and repeatedly heating samples of brick in a gas furnace, and then immersing in water. They are heated in the furnace to 2,000° or 2,200° F., are then immersed in cold water for one minute, then removed from the water and allowed to steam off for a couple of minutes until the water is evaporated from the brick, then re-heated and re-dipped, etc. It is exceedingly important in these tests that the time of immersion in the water be made absolutely uniform; if not, comparison of the various tests will be worthless. For accuracy, it is best to use a furnace large enough to heat three bricks simultaneously, and for more accurate comparison it is best that these should be different samples; still greater accuracy is obtained if there is used in every test a sample of one standard brick for comparison. Uniformity of condition is still further assisted by numbering the samples 1, 2, 3, etc., and then placing them in the furnace and removing and 'dipping' in constantly the same order. The temperature of the furnace should be maintained roughly uniform throughout an entire test."

The Bureau is able to submit below some analyses of two grades of fire brick made by a certain firm.

	New brick	Old brick
Silica	70.27%	67.75%
Oxide of Iron	1.90	2.45
Alumina	25.65	27.00
Lime	.95	.80
Magnesia	.42	.94
Potash (K_2O)	.22	.52
Soda (Na_2O)	.20	.41
Loss	.03	.13
Titanium	.23	.18
Sulphur Trioxide	.03	None
Copper	None	None

The foregoing answer as submitted by the Bureau of Information comprises data which we have been able to gather in the matter, and the Bureau also calls attention to analyses submitted below from three different firms of fire brick manufacturers. Names are withheld on account of advertising reasons.

No. 1.

"I wish to submit the following in regard to question No. 37 of the Bureau of Information.

We have furnished a great many brick at different times for checker work in carburetters and superheaters. We have furnished both what we call a 'mud brick' and 'dry press brick;' that is, brick made from stiff mud by the dry press process. We have found from our experience that the dry press brick gives the best satisfaction in this work and we believe the reason is that they stand the constant change of temperature much better than a mud brick, which is dense and distintegrates under the same conditions.

We do not believe in the use of a high-grade brick under these conditions, as they are usually hand-made and very porous; consequently, they take up a large amount of carbon and oil and soon become of no value as material for checker work. We believe that a brick between the high-grade porous variety and dense soft mud process brick is the brick that should be used under these circumstances. We do not

think the analysis of the brick would be of any consequence in this work and believe that the brick must be simply a good quality of fire brick.

We give herewith the analysis of our No. 1 Dry Press Brick which meets these conditions about as well as anything we know of:

Na_2O	.76
SiO_2	63.89
Al_2O_3	31.20
Fe_2O_3	1.85
CaO	.72
TiO_2	1.20"

No. 2.

"Replying to your favor of the 2nd in reference to question No. 37, below please find analysis of clay which the writer believes is the best for checker brick purposes. Of course, the brick will have to be mixed with the proper proportion of ground burnt material and plastic clay to produce a thoroughly good brick. From a manufacturer's standpoint, we would prefer not to give the mixture we use, but as the question merely refers to the analysis of the clay, we think this will answer to your satisfaction the question:

	Fire clay
Hydroscopic water	2.96
Water of composition and trace of organic matter	7.27
Silica	64.32
Alumina	22.82
Oxide of Iron, FeO	1.75
Lime	0.45
Magnesia	0.12
Soda	0.54
Potash	0.23
Sulphur	0.12
Phosphoric Acid	....
	100.58"

No. 3.

"The ideal analysis of fire brick, suitable for use in checker work in the carburetters and superheaters of water gas vessels, is as follows:

Silica	64.00%
Alumina	32.00
Iron	2.50
Lime	.25
MgO	.25
Alkalies	1.00
	100.00%

The texture of the clay should be massive, compact, hard, uniform, and coarse grained. The fire brick itself should be hard burned, with the pyritic iron to show black on the surface.

The brick should be finely ground, dense and hard. The average tensile strength of the brick should be from 75 to 90 pounds per square inch.

Running under heat tests, the brick should not show incipient vitrification below 2600° F., complete below 2800°, and should not be viscous below 3050°."

Question No. 38.

Answer by the Bureau of Information.

It would be almost impossible to state whether or not it would require a specific sum to heat the greenhouse mentioned in the above question, inasmuch as the cost would depend almost entirely upon climatic conditions, etc. However, the question can be treated along fundamental lines.

Assuming gas at 640 B. T. U.'s per cu. ft. and soft coal costing about $2.25 per ton at 11,500 B. T. U.'s per lb. the question of cost can be worked out as follows:

With coal having 11,500 B. T. U.'s per pound or 23,000,000 B. T. U.'s per ton and costing $2.25 per ton, the cost per million B. T. U.'s would be ten cents. With gas containing 640 B. T.

U.'s per cu. ft. it would require about 1562 cu. ft. to deliver 1,000,000 B. T. U.'s, which, if figured at 10 cents, equals 6½ cents per M., full efficiency being assumed in both cases. Any reasonable comparative efficiency for coal and gas heaters can be assumed by any one figuring a similar problem.

It is stated that plants make use of carbon dioxide in growth and that a moist and humid atmosphere is also favorable to the same end. The products of combustion of a completely purified gas would therefore appear to lend themselves particularly to this purpose. For this reason there might appear to be no serious objection to conducting the products of combustion which leave a heater direct into the greenhouse. In this manner the total heat of the gas is utilized and consequently the efficiency would be high. The Bureau makes this statement as a suggestion to be considered, but makes no claim as to having data, nor does it recommend same.

The greater cost of gas would also have a tendency to make the operators more cautious, and in that way the fuel waste would be reduced. The convenience in using gas must also be considered.

An installation for heating a greenhouse with artificial gas in the manner designated above was made by The Laclede Gas Light Company and was in actual service during the winter of 1903 and 1904. In this case the products of combustion were discharged into the atmosphere.

The greenhouse was exceedingly well built, mostly of glass, being new at the time of the above installation and contained about 3,000 square feet of radiating glass surface. The hot water heating system consisted of about 1,000 feet of 2″ pipe arranged along the sides of the building. The greenhouse was 110′ long by 20′ wide.

The system was installed as follows:

The return water from the system was run into a 6″ pipe on which were several 1¼″ connections or as many 1¼″ connections as there were heaters. Along the top of these heaters another 6″ pipe was arranged having the same number of

connections as the lower pipe, this pipe being the discharge pipe. In the above installation five heaters were connected up in parallel, the heaters being connected to the lower and upper 1¼" connections just mentioned.

It was the endeavor to keep the temperature in the greenhouse about 50° F. The greenhouse was started up during the latter part of December of the year 1903 and was heated with gas the remainder of the winter.

During the month of January the bill amounted to $90.00, February $80.00, while during the remainder of the season, or about two months, the bill was somewhat lower amounting to $50.00. Although the above greenhouse was only heated during the latter part of the winter, from the data at hand, it is estimated that the cost for the entire season would be about $400.00.

Fuel gas rate in St. Louis at that time was as follows:—

1st 10 M. cu. ft. through one meter in any one month .....80c. per M.
All above 1st 10 M. cu. ft. through one meter in any one month .....60c. per M.

The mean temperatures in St. Louis for the above months as secured from the United States Weather Bureau were:—

Jan. 27.8° F., Feb. 30.9° F., Mar. 44.9° F., Apr. 49.4° F.
Average B. T. U.'s of the gas was about 635.

The above installation was removed the following winter.

During the succeeding winters the greenhouse was heated with coal by means of a small boiler or water heater. The cost of heating the same with soft coal at $2.25 per ton during the coldest three months of the winter was from $18.00 to $20.00 per month, while during the remaining months the cost was about $10.00 per month; the cost for the entire season being $80.00. The coal averaged about 11,500 B. T. U.'s per pound.

Question No. 40.

Answer by the Bureau of Information.

It appears safe to say that at the present time no apparatus exists by which ordinary illuminating gas can be used in connection with "Prest-O-Lite" tanks.

The storage of acetylene in Prest-O-Lite tanks is not in the true sense compressing the gas, but rather charging it in the presence of acetone. The solubility of acetylene in acetone is what makes this process commercially possible. The solubility of ordinary illuminating gas in acetone, is possible to a very slight extent only, in as much as acetone absorbs carbon monoxide, hydrogen, and methane, the three chief constituents of ordinary illuminating gas, to only a fraction of its own volume. On the other hand, acetone dissolves approximately twenty-four times its own volume of acetylene at ordinary temperature and pressure and continues to dissolve it in the same proportion as the pressure increases, until the point of liquefaction is reached.

The cylinders as now supplied are filled with porous absorbent discs; these are saturated with acetone in an amount equal to about 43 per cent. of the volume of the cylinder. The cylinder is then charged with acetylene to a pressure of about 10 atmospheres, at which pressure it contains approximately 110 times the volume of acetylene available for use in comparison to its total capacity at atmospheric pressure.

The storage of Pintsch gas in tanks may be taken as the nearest approaching condition under which ordinary illuminating gas would have to be stored. For a given size cylinder, only one-tenth the amount of Pintsch gas can be stored at 10 atmospheres pressure, than is the case with acetylene in the presence of acetone. It would therefore follow that an ordinary illuminating gas, if stored under a pressure of ten atmospheres, would be practically stripped of its illuminating value, unless it were charged in the presence of some solvent that would make possible the storage of a greater quantity than could be compressed, without the loss of candle-power.

The discovery of some chemical compound, which would have the dissolving powers for the various constituents which go to make up illuminating gas, would be necessary before it would be possible to handle ordinary illuminating gas in apparatus at all comparable to the Prest-O-Lite tanks.

Answer-at-Large

By The Prest-O-Lite Company, per M. Moskowitz, Engineer, Indianapolis, Indiana.

We note question No. 40 in *Progressive Age* of January 1st, in the Bureau of Information column, and beg leave to answer same as follows:

1st: The actual available space in the standard Prest-O-Lite cylinder, packed with porous asbestos, containing absorbent liquid, is nearly 1/10 of a cubic foot, so that it would require 20 atmospheres pressure to get into these tanks no more than 2 cubic feet of city gas,—the absorbent liquid being totally unsuited for any gas other than acetylene.

2nd: Even if as much city gas could be put into the cylinder as is possible with acetylene, the lack of any suitable apparatus making it possible to use manufactured gas in automobile lamps and the relatively lower candle-power of manufactured gas per foot, as compared to acetylene, would render it out of the question.

We trust this party does not undertake to tamper with Prest-O-Lite tanks, as he is liable to hurt himself doing so,—it being apparent that he knows nothing about the subject.

Question No. 41.

Answer by the Bureau of Information.

The question in itself does not state whether the horizontal candle-power or the mean spherical candle-power is wanted, nor does it state in what kind of a burner the 100 cubic feet of gas should be burned. Owing to the absence of the above explanations on the part of the questioner, we assume that the information desired is the horizontal candle-power and the

burner to be used is the standard test burner. The answer to the question was compiled along these lines, also assuming time of burning to be same for both kerosene and gas, viz., one hour.

The following is a comparison of the number of candles of light obtainable from a gallon of kerosene oil burned in a flat wick burner, also in a round wick burner, and 100 cubic feet of gas burned in a standard test burner.

One gallon of oil burned in flat wick lamps, will give 733 candle-power.

One gallon of oil burned in round wick lamps, will give 1,100 candle-power.

One hundred cubic feet of gas, (18 candle-power)=360 candle-power.

One hundred cubic feet of the above gas burned in a good Welsbach burner would, in regular service, give an illuminating power five or six times as great.

As to further literature regarding this subject the Bureau wishes to call attention to a paper by Dr. A. H. Elliott, Chemist of The Consolidated Gas Company of New York, read before the annual convention of the Illuminating Engineering Society.

Inasmuch as data on such subjects as this naturally varies somewhat, the Bureau wishes to call attention to the two Answers-at-large submitted to this question.

ANSWERS-AT-LARGE.

By Carroll Miller, M. E., Consulting Engineer, Pittsburg, Pa.

100 cubic feet of 18 c.p. gas will give 360 candle hours when consumed in a flat burner, and about 2,000 candle hours, in an ordinary incandescent burner.

One gallon of kerosene oil (sp. gr., .790) will give 889 candle hours in a flat flame lamp, burning at the rate of 2.4 oz. per hour, and 946 in a round flame lamp, 4.57 oz. per hour. (Tests made in 1895 by J. P. Kennedy and Carroll Miller at the East River Gas Co.).

A. R. Egeler (Jl. of Gas Ltg., Jan. 1, '07) gives 56 grains per candle for a circular burner, 1.54 oz. per hour, which figures about 860 candle hours per gallon.

By C. B. Gamble, Omaha, Neb.

Below is a report on test of kerosene lamps.

Round wick lamp, "Rayo."

Length of test 10 hours.

Average candle-power 28.15.

Weight lamp beginning of test 2 lbs. 8¼ ozs.

Weight lamp end of test 3 lbs. ½ oz.

Put in 1680 cc.

8.25 cc. weighs ¼ oz.

Oil burned 1680—272.25=1407.75 cc.

$$\frac{1407.75 \times .061}{231} = .372 \text{ gal.}$$

$$\frac{28.15 \times 10}{.372} = 757 \text{ candle hours per gal. of oil or for 10 cents.}$$

Flat wick lamp.

Length of test 10 hours.

Average max. candle-power 9.44.

Average mean horizontal candle-power 8.14.

Weight of lamp beginning of test 3 lbs. ¾ oz.

Weight of lamp end of test 3 lbs. 1 oz.

Put in 360 cc. oil.

Oil burned 360 — 8.25 = 351.75 cc.

$$\frac{351.75 \times .061}{231} = .0929 \text{ gal.}$$

$$\frac{9.44 \times 10}{.0929} = 1010 \text{ candle hours per gal. of oil or for 10 cents.}$$

$$\frac{8.14 \times 10}{.0929} = 874 \text{ candle hours per gal. of oil or for 10 cents.}$$

This latter figure is obtained by using the mean horizontal candle-power.

Question No. 42.

Answer by the Bureau of Information.

It is not a good practice even in small works to test meters in the manner suggested. Tests made in this way are very unsatisfactory and at best only give a rough test in that new meters are often injured in shipment, causing valves to leak and meters to run slow.

A meter prover with attachments can be purchased and installed for about $150.00. It is as important to the Company as the station meter itself, and should be one of the first things purchased. The only satisfactory way of testing meters is by means of such meter provers. The amount saved in testing meters with the prover instead of the expensive way suggested would in itself probably warrant the purchase of the prover.

Question No. 43.

Answer by the Bureau of Information.

This heater is one in which the water circulates through a copper coil and is heated by a burner in the base. There is a deflecting cone in the center to throw heat around the coil. The outside casing is of Russia iron or brass.

The concensus of opinion secured by the Bureau is, that for sanitary reasons a vent pipe should always be used on such a heater.

On first lighting such a heater, imperfect combustion is brought about by the flame striking the cold coil. This is is more quickly overcome by the force of draught produced by the flue connection. If a damper is installed in the flue connection, greater efficiency may be obtained by regulating same to draw in the proper amount of air for complete combustion.

While the foregoing comprises the majority of opinion of the Bureau of Information, it is only fair to say that the following comments were received from one of the members.

The foregoing answer appeared to this member to be theoretically correct, but not practically so. He states that it is known that it is not necessary to use a vent pipe on kitchen water heaters, and that it is not commonly done; and that if the Gas Company insists on adding this expense, it would hinder the sale of such heaters. It is also known that copper coil heaters give much less odor than the old style all-iron heater, and that their use without vent pipe, though theoretically incorrect, is not in practice undesirable. An instance is quoted of such a heater being in use without a vent pipe, and its giving no odor whatever.

Finally, the Bureau in submitting it's answer to this question, would state that while the majority opinion appears to favor the connection, yet it would not advocate its use in practice, simply from its theoretical correctness, but would request each user of such heaters to give this question careful consideration, and decide the case somewhat from the viewpoint of local conditions.

The Bureau wishes to submit the following Answer-at-large by H. N. Gillette with Crane Company of St. Louis, Mo.

Answer-at-Large.

By H. N. Gillette.

Referring to the question No. 43 I wish to submit the following:—

"The general consensus is that this type of heater should have a flue connection,—especially the Lawson type, which employs a copper coil, as the action of the gas flame on the copper, it is claimed, creates a disagreeable odor. In the case of the "Ideal" Heater, where cast iron plates are used, it has been found satisfactory to install without venting."

Question No. 44.

Answer by the Bureau of Information.

The answer to the above question was compiled by obtaining information on the subject from an expert on the manufacture of paint.

In submitting the answer the Bureau wishes to call attention to the fact that in the manufacturing of all varnishes, it is necessary that the maker be thoroughly familiar with the work as the danger of ignition of explosive vapors is very great. Because of the danger involved it would be well, for any one desiring to go into this subject to communicate with some varnish or paint manufacturer.

The formula for the manufacture of the coal tar paint submitted is as follows:—

> "Put into a 220 'Iron Black Varnish Kettle' 400 pounds of coal tar, neutralized with a small quantity of Coal Tar Pitch, 200 pounds of 'F' Rosin, 120 pounds of Raw Linseed Oil and about 20 pounds of Black Oxide of Manganese. Cook until when dropped on a piece of glass will dry hard and brittle, then cool to about 250° F., then add slowly at first about 100 gallons benzole, or 62° B. benzine or turpentine. (The benzole will probably produce the best paint.)
>
> If material is required to be made more elastic use more linseed oil. In thinning down with the benzole or its equivalent, great care should be exercised and the adding of the thinning stopped the moment white fumes or vapors commence to flow."

The above varnish can be applied to iron or steel and will not have a corrosive effect.

Lime is added if necessary to neutralize any acid which may be in the coal tar pitch. This is generally considered as very essential. In some cases Portland cement is used instead of lime: it is doubtless sufficiently alkaline to serve the same purpose as the lime in neutralizing the acid.

In connection with the answer-at-large submitted by Mr. Carroll Miller, it may be stated that with the tar paint he describes, leaky tin roofs were made water tight; on the worst

places a coat was applied, then muslin was stretched over the wet paint, and after drying, an additional coat of paint was applied over the muslin. Temporary buildings have had their roofs made water tight and sightly. This coal tar paint will unquestionably stick to and thoroughly cover galvanized iron.

The data, instructions and discussions as given by Mr. Miller were published in Engineering News, July 12, 1906, August 16, 1906, August 30, 1906 and September 19, 1907.

ANSWER-AT-LARGE.

By Carroll Miller, M. E., Consulting Engineer, Pittsburg, Pa.

It is claimed and has been fully demonstrated that the following mixtures contain no acids which injure iron:

	Coal tar	Portland cement	Kerosene oil
New Orleans mixture	8	1	1
Annapolis mixture	16	4	3

The Portland Cement should first be carefully stirred into the kerosene oil, forming a creamy mixture. This mixture is then stirred into the tar, which must be free from water. The paint must be freshly mixed and kept constantly stirred when applying. (Am. Gas Lt. Jl., Oct. 1, '06.)

The cement neutralizes the acids.

There are many good paints made from tar oils, pitch and other products of distillation.

QUESTION No. 45.

The Bureau has prepared no official answer to this question, accepting the following answer-at-large as satisfactory.

ANSWER-AT-LARGE.

By J. L. E. Cheetham, Philadelphia, Pa.

The gas oils as used in the different parts of the country will consist of any one of the following oils:

(*a*) Crude Oil.
(*b*) Straight Run Oil.
(*c*) Mixed or "Slop" Oil.
(*d*) Cracked Oil.

It is evident, therefore, that the original or crude oil will vary from the distillate, and that the distillates will vary from each other according to how the crude oil was treated at the oil refineries. For that reason and since all investigations have been made on crude oil, the following results are based on the oil as it comes out of the ground.

The difference in the results between the crude oil and any form of its distillates will not vary to as great an extent in question *"a"* as in question *"b."*

Petroleums are classed according to their geological formation into fields. The principal fields are as follows:

(1) Appalachian consisting of the petroleums of Western New York, Pennsylvania, West Virginia, Southeastern Ohio, and Eastern Kentucky.

(2) Ohio and Indiana.

(3) California.

(4) Texas.

(5) Kansas, Indian Territory, and Oklahoma.

(6) Louisiana.

(*a*) What is the ultimate analysis of the gas oils from different parts of the country?

As will be seen the ultimate analysis of the oils from different parts of the same field will vary to some extent; the endeavor has been to give as nearly as possible the best results obtainable.

(1) Appalachian Field.

Location.....	Cumberland, W. Va.	Penna. crude	Penna. crude	Penna.
Spec. grav.		0.830	0.886	0.83
C	86.316	85.51	84.90	86.10
H_2	13.071	14.18	13.70	13.90
O_2	.....	.....	1.40	.....
N_2	.230	trace	.....	.....
S_2	.....	trace	.....	0.06
Authority	Peckman	Mayberry	Urqhart	

(2) Ohio and Indiana Field.

Location	Ohio	Lime	Ohio	Welker, Ohio
Spec. grav.	.....	0.831	.....	.8367
C	84.57	80.20	86.316	85.46
H_2	13.62	17.10	13.071	13.91
O_2	.....	2.70	.....	.....
N_2	.....	.....	0.230	.....
S_2	0.60	.....	.....	0.48
Authority	Mayberry		Peckman	Palmer
		W. S. Collins		

(3) California Field.

Location	Santa Barbara Co.	Fresno. Co.	Kern River	Santa Clara
Spec. grav.	0.9845	0.8423	0.962	0.8515
C	86.32	86.24	84.43	86.08
H_2	11.70	13.08	10.99	12.88
O_2	.....	.....	3.34	.....
N_2	1.25	.....	.65	.....
S_2	0.84	0.21	.59	0.92
Authority	Mayberry	Mayberry	U. S. Gov.	O'Neil

(4) Texas Field.

Location	Beaumont	Beaumont	Sour Lake
Spec. grav.	.924	.912 to .914	.....
C	84.60	85.03	85.96
H_2	10.90	12.30	13.97
O_2	2.87	.....	.....
N_2	.....	0.92	.....
S_2	1.63	1.75	.....
Authority	U. S. Gov.	C. Richardson	

(*b*) What is the percentage of the paraffine and benzine series compounds in the gas oils in this country?

The paraffine or methane series of hydrocarbons (C_nH_{2n+2}) and the benzene or aromatic series of hydrocorbons (C_nH_{2n-6}) exist to a more or less extent in all fields of this country with

the exception of the California oils, which do not contain any hydrocarbon of the paraffine series. The actual percentage of each series in the different oils would be impossible to give as all different compounds in the oil have not been discovered nor separated. Amount of solid paraffine has been determined in different oils but this would only be a part of the total paraffines in that oil, consequently the amounts of the paraffine and benzene series will be only qualitatively.

The petroleums of the Appalachian field consist principally of the paraffine series of hydrocarbons although series less rich in hydrogen have been isolated. Mayberry has found that the hydrocarbons of the series C_nH_{2n+2} are present with but few exceptions from butane boiling at —10° C. (14° F.) to one of the formula $C_{35}H_{72}$ and that probably of solid paraffine are present whose formula at present is impossible to obtain. Richardson has obtained 11 per cent. of solid paraffine in a residue of Pennsylvania petroleum having a gravity of .9202. Both Mayberry and Young have found considerable amounts of aromatic hydrocarbons. Young finds benzol in fraction boiling at about 65° C. (149° F.) and 66° C. (151° F.) and toluol to a considerable extent in higher fractions. Other homologues have been detected by Mayberry. Higher hydrocarbons of this series are known to exist but their actual structure has not been determined.

The hydrocarbons of the Ohio and Indiana field are principally of the paraffine series though in a smaller amount than the Appalachian field, likewise the aromatic hydrocarbons exist to a greater extent. The paraffine series corresponding to those in Pennsylvania oil have been isolated from butane boiling at 0° C. (32° F.) up to and including decane $C_{10}H_{22}$ boiling at 173° C. (343° F.). Above this, the liquid members fail. Solid paraffines, however, occur in greater amount than in Pennsylvania oil, the higher series from $C_{10}H_{24}$ boiling point 211-213° C. (411° F.-415° F.) atmospheric pressure, to $C_{17}H_{34}$ boiling point 177-179° C. (351-354° F.) 30 mm. pressure have been determined.

Mayberry has found the following of the aromatic series of hydrocarbons of benzol, toluol, and misitylene and higher homologues, including cumol, psuedcumol, cymol, isocymol, and doubtlessly others of higher molecular weights exist.

The paraffine series as far as is known do not exist in California oils. Homologues of benzol form a considerable proportion of the distillates of California oil. California oil differs from the eastern oil (Pennsylvania and Ohio) in not containing C_nH_{2n+2} (paraffine) series and the large proportion of the C_nH_{2n-6} (benzene) series of hydrocarbons.

The paraffine series of hydrocarbons exist in Texas petroleum to a slight extent. Richardson found 1.7 per cent. solid paraffine in oily residuum (sp. gr. at 25° C.—0.9735) from Beaumont oil. Benzine series have been isolated from Texas oil but the predominating hydrocarbons are the C_nH_{2n-2} and C_nH_{2n-4} series.

The oils from the Kansas field differ very widely in composition from oils of any other section. The very light oils are composed to a great extent of the C_nH_{2n+2} (Paraffine) series. The heavy oils, however, contain a small amount of this series. Richardson has found in the residuum of Kansas oil produced at the Neodesha Refinery 7.8 per cent. solid paraffine. The gravity of this residuum was .9328, thus making this oil rank next to the Appalachian field and Ohio and Indiana field in quantity of the paraffine series.

The Louisiana field is similar to the Texas field and consists chiefly of the hydrocarbons of C_nH_{2n-2} and C_nH_{2n-4} series.

Question No. 46.

Answer by the Bureau of Information.

In compiling an answer to this question, the Bureau of Information will confine itself to a general statement of conditions.

If a meter is removed on account of the money collected not equaling the gas consumed, and if the meter shows no defect in its mechanism, either in the meter or prepayment de-

vice, it becomes quite a question as to the reason of the shortage.

Some of the means of tampering with the prepayment mechanism, or the meter, so that no trace of the work subsequently could be detected, are as follows:—

One of the members of the Bureau found that a loose money box will often admit of the shaking of money from the box, by disconnecting the meter and turning it upside down. This may be obviated by placing seals on the connections.

Cases have often been found where ice discs have been used successfully in place of coins, the ice melting leaves no trace behind but the rusty interior of the box, and iron rust on such coins as may be in the box.

The locks may be worked by means of keys made of various substances.

The Bureau wishes to call attention to an answer-at-large to this question, contributed by Mr. Wm. A. Castor, Supt. of Meters, United Gas Improvement Company at Philadelphia. This goes into the question concerned in a very satisfactory way.

Answer-at-Large.

By Wm. A. Castor, Philadelphia, Pa.

The following is written as an answer to question No. 46 printed on page 31 of the January 1st, 1909, issue of Progressive Age.

Considering that the meter removed for a money short condition has been thoroughly examined by a man familiar with all details of the prepayment mechanism and that no trouble in same has been detected, the explanation of the shortage is problematical.

There is the possibility of the wrong size of index in the meter, the improper prepayment gearing for the price at which gas is sold, the failure of the gear wheels to properly mesh at all times, dirty or cocked cut-off valve, weak buffer, tampering

by the consumer or other parties, of which no evidence could be detected, robbery by our own employees or other persons through the use of cash box lock keys or the ability to open the locks by other means, the failure to properly credit the meter with the amount of money actually lifted, the lodging of coins in the gear box, and perhaps other cases which we have failed to enumerate.

In Philadelphia, the greatest cause for money short conditions, where no positive evidence of damage, defective gearing or tampering is obtained, is the slippage of the coin carrier in the direction of buying, due to a weak buffer or as the result of a jambing of some part of the prepayment cut-off mechanism or failure of the cut-off valve to close down properly. Where evidence of coin carrier having been out of line is detected, it is advisable to consult the consumer's history card, to find out if the meter has been visited one or more times by complaint men and coin carrier actually found out of line and adjusted by the complaint men at the time of the visits. In all cases of weak buffer the same practice should be followed in reference to looking up the visits and work done by the complaint men to the meter in question while setting in the consumer's house.

It should be borne in mind that the actual cases of removal for money short conditions constitutes but a very small percentage of the total number of prepayment meters in service, and that many of the meters thus removed are not found defective in any way. In Philadelphia, during the past year, about 1½ per cent. of the total prepayment meters in service were removed for the reason of money short, and at least 40 per cent. of the meters thus removed were not found to be defective in any of the prepayment mechanism parts. The system employed in the above mentioned city is to remove a prepayment meter as soon as a shortage between cash lifted and gas consumed, together with the credit shown on the credit dial, shows a shortage of fifty (50) cents. This system is bound to result in the maximum number of removals for the

reason of a shortage in the money lifted from the prepayment meters.

It should be remembered that the proof of the meter in service has absolutely no bearing on the comparison of money lifted with the index reading at any time.

Question No. 47.

Answer by the Bureau of Information.

In securing an answer to this question the Bureau was confronted by some technical difficulties. In the first place, the following is to be noted:—

In Circular No. 98, U. S. Department of Agriculture-Forest Service, entitled "Quantity and Character of Creosote in Well Preserved Timbers," Dr. Gilbert Alleman makes the following statement:—

"Technically speaking, the fraction of oil passing over between 240° C. and 270° C. during the first distillation of the crude coal tar is known as 'creosote oil,' 'heavy oil,' or 'dead oil of coal tar.'"

And further,

"The creosote oil of commerce contains phenol (carbolic acid), the ortho, meta, and para cresols, naphthalene, the A and B methyl-naphthalenes (the former being a liquid, the latter a solid melting at 33° C.) anthracene, phenantherene, acridene, and small quantities of certain high-boiling bases and acids."

Accepting the foregoing as covering the definition of a creosoting oil, there is none obtainable from water gas tar, since this tar will yield no phenols or cresols.

If the inquirer wishes to know whether there is any wood preserving oil obtainable from water gas tar, then the answer would be different. Practically, however, if we interpret the question so that the inquirer merely wished to know how much oil, heavier than water, can be obtained from coal gas and water gas tar, the question is more easily answered. The

general run of experiences of coal tar distillers is that about ⅓ of a gallon of oil is obtained from one gallon of coal tar. This includes both light and heavy oils.

As a practical example a certain coal tar made from Youghiogheny coal gave the following results: The yield of creosote oils from coal tar amounted to 22 per cent. and from water gas tar to 29 per cent. Chemically, however, the coal gas tar showed only 4 to 5 per cent. of creosote and carbolic oils, while the water gas tar yielded none.

It may be stated that in creosoting plants where oils from water gas tar are used, it is customary to mix them with coal gas tar oils in such proportions as may be specified by the purchasers of the creosoted timber.

ANSWER-AT-LARGE.

By Carroll Miller, M. E., Pittsburg, Pa.

The percentage of creosote produced will vary with the quality of the tar and the coal from which it is produced. An ordinary retort house tar, sp. gr. 1.21, containing about 20 per cent. of free carbon, will yield in the neighborhood of 24 per cent. by weight of middle, heavy and anthracene oils, which will amount to 60 gals. of creosote per ton (2,240 lbs.) of tar. The sp. gr. of this creosote will be about 1.05. However, if the specifications are very strict, the yield of creosote will probably be less, as it is very doubtful if the whole of these oils can be used for producing a creosote of the required quality. For details and specifications, see Circulars Nos. 80 and 112 of the U. S. Department of Agriculture-Forest Service. For reasons mentioned above, no definite figures can be given for the yield of creosote from any particular tar unless details regarding the tar and the quality of creosote desired are stated.

From 40 to 50 per cent. by volume of middle, heavy and anthracene oils are obtained from water gas tar produced from Pennsylvania gas oil. The quality and quantity of the creosote will vary in accordance with the quality of the oil and the temperature at which it is gasified.

Question No. 48.

Answer by the Bureau of Information.

The superiority of the piece-work system over the day-work system may be summed up briefly as follows:—

The piece-work system permits the foreman to spend practically all the time inspecting the quality of the work performed, whereas the day-work method requires constant vigilance to insure both quality and quantity of labor performed.

The piece-work system increases the amount of work performed by each mechanic as it is to his interest to study how to accomplish the work in the least time and in such a manner as to pass inspection.

The quality of the work in the piece-work system is superior, as the mechanic knows that unsatisfactory work will be rejected, requiring him to expend additional time without remuneration.

The piece-work system is to the advantage of the mechanic, as he derives remuneration in direct ratio to his efforts. As the result, the mechanic tends to accomplish more and better work.

The control of labor is better with piece-work system.

The success of either system requires the same careful inspection to insure good work, but the mechanic is better satisfied, and is able to make a greater amount of money that he would by day work. The best men average about $25.00 per week, the poorer ones $12.00, whereas the average wage for day-work would not exceed $3.00 per day.

The Bureau wishes to submit the following answers-at-large to the above question:

Answers-at-Large.

By George Beadenkopf, Engineer, Consolidated Gas, Electric Light and Power Co., Baltimore, Md.

The important matter in making meter repairs either by "day-work" or "piece-work" is that all completed repair work should be subject to rigid inspection by the foreman of the shop or his assistant. Both systems are in use in the meter

repair shops of this company; but the piece-work system is confined to the following classes of work:

"Putting in"—(putting in diaphragms).

"Casing in"—(putting on backs and fronts).

"Fitting and indexing"—(grinding, setting and packing valves and replacing indexes).

All adjusting and proving is done by "day-work." No "piece-work" is allowed on this character of work.

"Piece-work" is only permitted to be done by experienced workmen, and there is a limit put on the amount of work which a man is allowed to turn out under this system; for if he is allowed to do as much work as he possibly can, it is apt to be slighted. Whenever any "piece-work" is found to be defective, it is made good by the workman at his own expense.

Our experience is that about 10 per cent. more work is turned out by a man working under the "piece-work" system, and the work done is of as good a quality as that done by the "day-work" system. The work itself is therefore no cheaper, but under the "piece-work" system, the output of the shop is increased without any additional force.

Under our "piece-work" system, we allow only meters of 10-light and under to be repaired. All meters over 10-light are done by "day-work," because in the larger meters, the repair work is usually more difficult.

The number of meters handled annually through the shop is 20,000 to 25,000. The rates paid under the "piece-work" system are as follows:—

"Putting in," 12c. per meter. (Average amount of work per man, per day, 18 to 22 jobs).

"Casing in," 5c. per meter. (Average amount of work per man, per day, 38 to 42 jobs).

"Fitting and Indexing," 16c. per meter. (Average amount of work per man, per day, 15 to 18 jobs).

The average rate of wages for a meter repairer is $2.50 per day, of 10 hours, and under the "piece-work" system, a man can increase his wages to about $2.75 per day; all of his work, as stated above, being subject to a close inspection.

By Frank Hellen, Superintendent, Rochester Ry. & Light Co., Rochester, N. Y.

I believe that there are two kinds of work in connection with meter repairing that can be done under a "piece-work schedule" to advantage, and they are the soldering and re-soldering of the cases and the dipping of meters. All other work relating to meter repairing I believe to be too important for "piece work."

The oiling of diaphragms, the re-packing of stuffing boxes, and the grinding of valves, etc., is a line of work that can be very readily slighted unless the inspection is especially rigid, which means more help for inspection.

I think there is no other work connected with the gas distribution as important as the first-class repairing of gas meters, and for this reason I believe it to be impossible to work out a satisfactory "piece-work schedule," at least this has been the experience of the writer.

By V. F. Dewey, Supt. Mfg. & Distri., Detroit City Gas Co., Detroit, Mich.

In all work in connection with gas meters, there are two elements which enter into the proper answer of this question.

First, Quality.

Second, Cost of work.

The "piece-work schedule" will reduce the cost of meter repairs:

First, by making it an incentive for the men to work more constantly.

Second, To work faster.

Unfortunately, it also tends to make them slight the work. It is almost impossible to standardize the length of time that

it takes to make different repairs and without a complete standardization of repairs in which the time taken to do each different item of repair work is noted, it would seem impossible to satisfactorily work out a "piece-work schedule."

In working men on a strictly "day-work plan," it is possible to more closely supervise the work, also to obtain more individuality on the part of the men. Men will be more careful in their work, and the question of the amount done will be secondary to the quality of the work done.

By W. K. Harrington, Genl. Supt. Meters, Consolidated Gas Co. of New York.

The men doing meter repairs in this company have always been on piece-work, with the exception of the first two weeks when I took charge of the meter shop twelve years ago. Piece-work seems to be much the best way to handle this class of work, as it gives a good man a chance to earn what he is capable to earn. Our best average about $25.00 per week, and the poorer ones $12.00 per week, the average being about $18.00 per week. We generally start men on day work at from $1.75 to $2.00 per day, and as soon as they are proficient are placed on piece-work. With the piece-work system it is only necessary to watch the quality of the work, but the day-work it is necessary to watch not only the quality of the work, but the amount performed; and where the men are paid a varying rate of wages on day-work, or receive a bonus for doing more work than a stipulated amount, it virtually amounts to piece-work.

By E. J. Bartel, Supt. Meter Repair Dept., The Brooklyn Union Gas Company, Brooklyn New York.

Following is a report of prices paid by the Meter Repair Department for repairing meters. Various shops have different systems of working, and pay for repairs at the rates of from $2.50 to $3.00 per day, and repair from sixteen to twenty-three meters per week, including adjusts oiled and diaphragms.

From data collected, our method of piece-work is less ex-

pensive and we get more meters for delivery. I, myself, approve piece-work at our prices. We did have day's work at the company's shops, but have changed the same to piece-work.

PIECE-WORK REPAIRING METERS.

Sizes	3	5	10	20	30	45	60	100
Adjusting	.42	.44	.58	1.05	1.32	1.49	1.71	2.31
Oiling	.66	.75	.97	1.49	1.93	2.15	2.26	3.14
Diaphragms	.99	1.02	1.19	1.90	2.26	2.31	2.53	4.51
Condemned	.22	.28	.30	.42	.47	.58	.69	1.16
Pipes	.06	.07	.13	.19	D.W.	D.W.	D.W.	D.W.
Bottoms	.22	.28	.33	D.W.	D.W.	D.W.	D.W.	D.W.
Cones	.05	.05	.06	.06	.10	.10	.10	.10

Above 100 lights, day's work, at $2.50 to $2.75 per day.
Average per man, per week, 30 meters.

DAY'S WORK.

Gasing	$1.75 to $2.00 per day,	80 to 100 meters.
Toping	1.75 " 2.75 " "	80 " 100 "
Proving old style	2.50 " 2.75 " "	40 " 44 "
Proving automatic	2.75 " "	110 " 130 "
Painting	1.00 " 2.00 " "	100 " 200 "

By B. H. Spangenberg, E. Orange, N. J.

The fact that shops manufacturing new meters are for the most part operated under the piece-work system would lend weight to the argument that large meter repair shops should be similarly operated.

The specializing of different parts of the work in all kinds of factories is a firmly established practice, and this specializing of the work has led inevitably to the piece-work system or its equivalent.

Provided that proper inspection at each stage of the work is enforced, and also that a workman of fair average ability is *assured* of a fair average wage, the piece-work system has the following decided advantages:—

1—It weeds out the drones and inefficient men.

2—It assures a fair wage to the average workman.

3—It enables the workman of extra ability to earn, in proportion to his ability, more than the less efficient workman.

4—It stimulates the productive capacity of the men, and thus adds largely to the output, with a consequent reduction in the "fixed charges" portion of the cost per piece.

5—It invites workmen of the better class to apply for, and try to hold, by the quality and quantity of their work, positions more profitable to them than those under the day work system.

I think these arguments for a piece-work system are as applicable to a large meter repair shop as they are to any other line of manufacturing.

By Wm. A. Castor, Sup't. of Meters, United Gas Improvement Co., Philadelphia, Pa.

In the Philadelphia Meter Repair Shop, a modified form of the piece-work system has been adopted. This system requires each man to perform a certain number of operations, of a particular nature, as a day's work, and for which he receives a stated wage. In addition to performing the above work, a certain amount of extra or premium work is allowed for each operation and for which a stated price is paid. Each man is required to accomplish the rated day's work and then is allowed the full number of premium operations or less, depending on his ability to do the work.

We are assured of obtaining a fairly constant output from the shop, as a whole, by this method, but at the same time the maximum amount of work is not obtained from each and every man working under this premium system. The endeavor of every establishment is, or should be, to turn out the maximum amount of work per employee and per machine, and until this is accomplished the work cannot be turned out at the lowest cost, due to the fact that certain fixed charges, superintendence and inspection do not increase with the in-

crease in the output of finished work due to the introduction of the piece-work system.

The piece-work system, to my mind, offers so many advantages to both employer and employee, that there is nothing to be said in favor of straight day work system.

The question has been raised as to the inferior quality of work turned out by the piece-work system. The quality of work under any system depends entirely upon the thoroughness of the inspection to which the work of each man is subjected, and equally as good work can be turned out and as high a standard can be maintained under the piece-work as under the day-work system.

The proper rate to pay for each class of work, or for each operation performed under the piece-work system, must necessarily be carefully determined. The quantity of work in every case, constituting a fair day's work for a man, can be and has been determined. With this as a base to work upon, the rate for each operation can be easily set so that the man who is only able to do a fair day's work will be enabled to earn a fair livable wage, while the more skillful fellow-workman will be enabled to make the better wage, to which he is justly entitled.

It should be borne in mind that it not practicable to place all men working in the meter repair shop on either a premium or on a piece-work basis, as certain work must necessarily come under the laboring and apprenticeship classes, and for which it would be difficult to fix any piece-work prices.

A great deal more could be said at this time in favor of the piece-work method of paying employees, but I think the following paragraphs, embodying the ideas and experiences of our foreman, Mr. B. G. Waggner, will convey the true story, as having been told by a man who has had experience in various meter repair and in new meter shops, with both systems of paying the employees. Mr. Waggner has carefully noted the conditions and has here plainly stated same as they have come under his observation.

"The advantages of the piece-work system are in my opinion, so great that the day-work system is not worthy of consideration, where there is a large number of meters to handle in the meter repair shops.

In the first place, piece-work allows the shop to turn out the maximum number of meters, consistent with the quality of work desired, with the minimum amount of labor. The quality of the work is very readily maintained with proper supervision.

In proportion to the volume of work turned out, the amount of supervision necessary is not as great as is required in the proper conducting of the day-work system, in a large shop. This is accounted for by the fact that with piece-work there are fewer men to look after, in comparison with the number of meters turned out, and that it keeps most of the men moving "in the right direction," while in the day work system the men soon learn to keep busy while doing very little work. And even when you impose a given task upon men, they learn to make this task easy and to do the actual work in as little time as possible; the rest of the time is taken up in doing unnecessary work, such as extra wiping and polishing the meters. I have seen just as poor work done under day's work as under piece-work.

The natural inclination of most every man is to be fast, and if possible a little faster, with his work, than the man next to him. This results in them racing through their work and then filling in the remaining time in some useless manner. I have worked in quite a few shops conducted under both systems and in every day work shop there has been one or two men who are disliked and talked about by the rest of the men for rushing the work and taking chances on "killing the job," while in the piece-work shop it is conceded by all to be a man's right to do as much work as will be allowed him. So that the *proper* supervision and inspection of the work is pretty near even under both systems. There is another thing to consider in the possible slighting of work, and that is,

under the piece-work system you set the desired standard of work and you can maintain it by causing the men to know that standard must be lived up to. This is easily done after one or two men have been discharged for slighting of the work in the endeavor to turn out a large volume. On the other hand, with a day-work system, the man who slights his work by rushing is likely to be tolerated because he serves as a "pace-maker."

I have always found a greater feeling of content among the men of a piece-work shop than among those of a day-work shop, due, no doubt, to the fact that most of their time is taken up with their work and not with thinking of and talking about petty or fancied grievances.

Summing up the subject, I would say that piece-work was the better system of the two, for the reason that just as good a quality of work can be maintained under it as under day-work and at a greatly reduced cost per meter, and that greater justice is done the men, for the reason it allows every man to earn wages according to his ability, and also for the reason that the men are better satisfied and therefore more easily managed.

The shop force, under a piece-work system, will eventually consist of the best workmen obtainable, as the good man invariably hunts the shop where he can make the most money, and the slow, indifferent or incapable workmen are soon detected and weeded out.

In conclusion, I would say, that I have seen several large shops go from the day-work to the piece-work system, but I have never seen one change from a piece-work basis back to a day-work basis."

Contribution.

The question of piece-work or day-work to be established in any meter repair shop is dependent primarily upon but one consideration—the quantity of work in hand to busily employ at fixed tasks the employees engaged. A man working piece-work, cannot produce results if his piece-work is spasmodic

and broken into by hour time work or day work, or to the same extent interfered with while waiting on material or meters to be handled.

Under this condition with the majority of the smaller gas companies it is much more preferable to work with one or two men in the meter repair shop on a day-work or hour-work principle in that the repair men, who are generally more or less mechanical can be used on a great variety of other work, and in this manner, be much more liable to earn their wage for the employer.

On the other hand, with a large shop where a continuous quantity of meters are being handled, the piece-work system is unquestionably the better, as there is no doubt but that the introduction of piece-work rate sometimes accompanied by premiums or payment of bonus particularly for good workmanship, etc., will create from the start a general "quickening" of all employees; this characteristic "quickening" is readily recognized and is of itself the best indication that more actual work can be accomplished in a large well organized shop under the piece-work system per unit of time than under any system of day labor.

In the handling of a piece-work organization it is well to give consideration to several essential points. As stated, the undertaking must be of sufficient magnitude to constantly employ the men engaged in the actual repair of meters.

Again the supervision of any meter repair shop, particularly when working on a piece-work basis, must be strict and exacting, and yet at the same time, this supervision must be in sympathy with the object sought, namely the lowest possible labor cost consistent with good workmanship—and at the same time consistent with a fair remuneration to the employees—and again the supervision or direction of the actual operation of a meter repair shop, particularly under the piece-work system, should be entrusted to a man with good knowledge of the work to be accomplished and who is enthusiastic, without ideal dreams, and above all the man should be practical to the extent

of having had some knowledge of the detail of the actual work to be performed.

This question of superintendent is a thought to be dwelled upon, as a man in this position to obtain good results under a piece-work system must be resourceful in adapting the work to whatever system may be installed, and at the same time he must be tactful in dealing with his employees, and to a degree must accept their view-point, and yet mould same to his own advantage as well as to the advantage of his employees.

He must have a keen appreciation of fairness and truthfulness and its value to him in maintaining his position with his men, especially as a piece-work rating is merely a refinement of the old style set tasks for different men. The operation under piece-work being really the introduction of the right prices for the right tasks, both to be equitable not only to the employer, but to the employees as well.

Addendum to Question No. 48.

The Bureau of Information wishes to submit this resumé of the meter shop practice of various gas companies as an addendum to its answer to Question No. 48. This resumé consists of a letter from each company, which letters are as below:—

St. Paul Gas Light Co., St. Paul, Minn.

Replying to inquiry of the 5th inst. as follows:—

Meters passed through shop.

1906	6,762
1907	5,961
1908	8,926

Employees of shop.

One foreman.

One meter repairer.

Two apprentices.

We pay all our employees by the hour but make a check on each class of work similar to a piece-work system. Each

man shown distributes his time on his daily card to show number of hours and number of meters tapped, oiled, back plates removed, valves ground, meters tested, adjusted, etc.

This has proven the most satisfactory method for us, our shop force being too small for a piece-work system.

Very truly yours,

ST. PAUL GAS LIGHT COMPANY,

(Signed) B. F. PELTON,

Sup't. Dist. Dept.

THE PEOPLES GAS LIGHT AND COKE CO., CHICAGO, ILL.

Your letter to Mr. E. G. Cowdery of this company has been handed to me for reply.

During the past year we handled, through our meter shops, approximately 85,000 meters.

Our present practice is to employ men on an hour basis, ranging from 15 cents to 30 cents per hour, 10 hours per day. We endeavor to fix and increase his hour rate in keeping with his recognized ability.

The same arguments for and against either day-work or piece-work in any shop work are applicable, in my opinion, to meter shop practice. New York uses the piece rate; Philadelphia premium plan; Baltimore a combination, which is practically a piece rate.

I favor paying *bench hands*, where their work each day is practically a repetition of the previous day's work, in such a way that there will be a *natural* and *constant* endeavor on the part of the man to do as much as he is *capable* of doing each day, independent of what his weaker or stronger fellow employee may do, or what he himself may have formerly done.

So much per day does not contain the necessary incentive On the other hand, the determination of proper piece rate is difficult and entails system, etc., so much so that I would not advise its introduction in small shops.

We are now arranging our work in such a way that, should

it seem feasible after further investigation, we can adopt a premium or bonus plan, equitable to our employees as well as ourselves.

Very truly yours,
(Signed) CHAS. C. SCHILLER, Supt. of Meters.

San Francisco Gas and Electric Co., San Francisco, Cal.

In answer to your letter of February 5th, I wish to state as follows:—

We run our meter shop on a day-work basis with a standard of minimum output per man, and find, with a good foreman who thoroughly understands the work, that it proves very satisfactory, and, I believe, superior to piece-work.

We have ascertained the time required for each separate operation and a cause must be shown when the time is overrun.

The number of meters passed through our shop during 1908 was 25,233; 22,883 being repairs, and 2,350 repairs and renewals of diaphragms.

There were eighteen men employed; counting three hundred working days at eight hours per day, this will show an average of one hour and forty-five minutes spent in repairing each meter.

Hoping that this will answer your question satisfactorily, I am,

Very truly yours,
(Signed) E. C. JONES.

Indianapolis Gas Company, Indianapolis, Ind.

Replying to yours of the 5th, we beg to advise that during the year 1908, 14,472 meters passed through our meter repair shop. Our force of men in this shop during the year consisted of one foreman, 3 repair men, 1 tinner, and one boy. All work done was done by day-work. We have always felt that in the piece-work schedule, we would not get satisfactory results without having thorough inspection by a competent inspector.

and do not believe that there would be any advantage to us in making a change at the present time.

Very truly yours,
(Signed) Carl H. Graf, Genl. Mgr.

Buffalo Gas Company, Buffalo, N. Y.

We repair all our meters by day-work and as I have never had any experience with piece-work, I am unable to give an opinion as to the comparative value of the two systems. In either case the method of management is a very large factor.

Very truly yours,
(Signed) H. C. Palmer, Engineer.

Central Union Gas Company, New York.

In answer to the questions asked I beg to say that our meter shop repaired 25,575 meters of the various sizes in 1908. All this work was done by piece-work, and believe it to be the most satisfactory method of handling it.

Yours very truly,
(Signed) A. H. Hall, Asst. Secy.

Tri-State Gas Company, Steubenville, Ohio.
(Branch Office.)

Your favor of the 5th to Mr. H. B. Beatty, President of the Manufacturers' Light and Heat Company, was handed to me. In reply would state that I do not believe it would be to the best interests of the Gas Company to have their meter repairing done by piece-work, as an employee a little negligent, and hurrying up, might do work that would be very expensive for the gas company. I believe a good employee will do better work and be more particular on a day or monthly salary.

We cannot give you the number of meters passing through our shop per year, as prior to this year, the party repairing the meters was on other work, which was not kept separate from the time put on the meters.

Some meters will cost us 25c., while others, where we have to put in a new diaphragm, would be from $1.50 to $2.00; and

again, where a meter has passed through fire, the cost would probably be $4.00. I remain,

Yours very truly,

(Signed) E. C. Beatty, Superintendent.

Westchester Lighting Company, Mount Vernon, N. Y.

In answer to the American Gas Institution question No. 48 in your letter of February 5th, would says as follows—:

No. of meters repaired by W. L. Co., all meter repair work done at Central Union shop.

	Reg.		P. P.		
Lt.	Dia.	C. & O.	Dia.	C. & O.	Cover arms
3—	723	87	238	86	50
5—	822	154	444	288	69
10—	151	29	7	4	25
20—	27	3	0	0	1
30—	3	2	0	0	0
45—	4	1	0	0	1
60—	3	0	0	0	1
100—	3	0	0	0	0
150—	1	0	0	0	0

I called up Mr. Hall, who is superintendent for the Central Union Gas Company, and asked him his opinion as to shop work, and he said his opinion was that it was the best system.

Hope this gives you all the information requested in your letter of the above-named date.

Yours truly,

(Signed) G. T. Macbeth, E. G. D.

Milwaukee Gas Light Company, Milwaukee, Wis.

I have your inquiry of February 5th and would say that we pass through our shops upwards of thirty-five to forty thousand meters per year. All work is day-work.

As regards the advantages of this method, I can only say that we have been trying hard for several years to get

our meters into the best possible condition, and recent comparison of the average of a large number of meters taken from the test records of five of the largest companies in this country and classified under the term for which the meter has been in use, shows our meters to be in good condition, if not a little better than any of the others.

For the small saving to be effected I would not under present conditions want to change to a piece-work basis, though undoubtedly if properly systematized and safe-guarded by check inspection in a large shop considerable economies could be shown by that system.

Yours truly,

(Signed) Milwaukee Gas Light Co.,
R. B. Brown, Engineer.

The New York Mutual Gas Light Company, New York, N. Y.

Replying to your favor of February 5th regarding the question of meter repairs, I beg to say we are repairing about 1,500 meters per month, and eveything is piece-work up to 30 lights. everything above that is day-work. We make our diaphragms and consider piece-work more satisfactory than day-work, especially where we have so much of it to do. We get a good many good parts from the old condemned meters for repairs, and find a sale for all meters condemned at a small price, and do not find it necessary to condemn nearly as many as when sent to an outside factory for repairs.

Yours very truly,

(Signed) Walter A. Allen, Engr. & Supt.

Los Angeles Gas & Electric Co., Los Angeles, Cal.

Replying to your favor of the 5th instant. Below I give you answers to questions in the order asked.

Number of meters passed through shop during year, 24,934.

All of our men are paid by the month.

There is not enough of any particular branch of work to adopt a piece-work system. Furthermore, practically all our

work is general repairs, and a certain amount of work is often required before it can be determined just what will be necessary in the way of repairs, consequently men are employed who are fitted for general repair work.

Trusting that this will be satisfactory, I am,

Yours respectfully,

(Signed) C. S. VANCE, Mgr. of Operation.

Louisville Gas Company, Louisville, Ky.

Replying to your inquiry of the 5th inst., the number of meters passing through our repair department, including all meters brought in for test last year was about 16,000. We have never considered the advisability of piece-work.

Respectfully,

(Signed) A. H. BARRETT, Engineer.

Minneapolis Gas Light Company, Minneapolis, Minn.

Yours of Feb. 5th received and contents noted. Will say in reply that I do not think that piece-work in a meter repair shop, for large companies, would be satisfactory, as the number of meters the company has to repair does not come regularly enough; at least, that would be the trouble in Minneapolis. While we handle all our meters every three years, during the period of changing we are very busy. After that period, which only lasts about three months, we are then running along on regular removes and sets and general repairs, which does not keep a very large force at work.

From practical experience myself in piece-work in the mechanical lines, I believe that it leads all mechanics to slight their work in order to turn off a greater volume. Of course, a man doing one thing all the time becomes very expert at it; but he also learns very quickly to deceive his foreman and get work passed that is not absolutely right. It is human nature than when you have a stint on any class of work, to make just as much money as possible out of it, and they will cut the corners in every conceivable manner.

The great trouble, in my judgment, with the majority of meter shops in large companies, is from the fact that they have a foreman in charge who is a dead man, only looking for Saturday night and pay-day, and to run the shop and keep a number of men along with him who will cause as little inconvenience to his own personal welfare as possible. This was the difficulty experienced in Minneapolis, and in order to overcome it, I had to take an absolutely green man and break him into our shop methods and then give him charge of the shop, and I think he has made a decided success, so far as we are concerned.

The meter is something that we cannot afford to fool with or to have repaired and go out to its work without being absolutely correct, as we receive plenty of criticism from the very best possible methods known. During the year 1908, we passed 32,508 meters through our shop with a little handful of men. The cost of handling these meters is very small.

Very truly yours,

(Signed) F. C. Shepard, Superintendent.

The Denver Gas & Electric Company, Denver, Colorado.

Answering question No. 48 of the Information Bureau of the American Gas Institute, would say, that although I have worked for reasonably large sized companies, I have never had any experience with the making of meter repairs under a "piece-work schedule." The foreman of our shop, Mr. Lembach, has been a meter repairer for the past eighteen years, and neither has he had any experience on other than day-work.

Personally, I would not advocate the piece-work plan on meter repairs, as I am satisfied that mechanics working under this scheme would be tempted to slight their work, and it would be a very difficult matter to check up the one at fault, and it would also be necessary to penalize the men when their errors were discovered and located.

We have about 30,000 meters installed in Denver, and we aim to take out at least 10,000 every year, so that at the ex-

piration of three years every one of our meters have been tested and put through the prover, which practically amounts to what we term our routine test.

As stated above, our shop practice is day-work.

Yours very truly,

(Signed) M. E. Malone, Supt. Gas Dept.

Question No. 49.

Answer by the Bureau of Information.

We were unable to secure any experiments on this matter and are obliged to submit an answer comprising the experiences of several of the members of the Bureau in the past.

From tests which have been made in the past and observation would say that the extent to which the hydrocarbon vapors would be oxidized by the admission of 1 per cent. of air at the mouthpieces depends largely upon the temperature of the gas at the point of air admission and also upon the rapidity of cooling after the air has been admitted, in other words, the time of contact of the air with the gases at a temperature sufficiently high for oxidation to take place. The temperature at the mouthpieces varies in different works according to conditions all the way from 300° F., and obviously at the latter temperature oxidation would amount to combustion with formation of carbon dioxide, carbon monoxide and possible deposition of free carbon. The chemical reaction would probably be a complex one and a long series of tests at different temperatures would have to be made to determine its nature.

The Bureau regrets that it is unable to give a more complete answer to this question.

Question No. 50.

Answer by the Bureau of Information.

In order to overcome the fluctuation in pressure caused by the intermittent suction by a gas engine on the gas supply line, it is necessary to have a reservoir of gas, which can be sup-

plied continuously from the meter without the pressure being affected by the intermittent charge given to the engine.

Owing to the hit and miss governing of most gas engines, the gas is not used by the engine at a constant rate per minute.

The use of a rubber bag or solid tank will not entirely prevent the fluctuation of the pressure unless it is very large. Assuming a maximum pressure of 2 inches and an allowable fluctutation of two-tenths inches, the volume of a solid tank to supply a charge to the gas engine would have to be about 12 times the cubic feet of gas consumed per minute. This, making allowance that one-fourth of the charge is being supplied to the tank while the engine is drawing the full charge out. This is obtained by using Boyle's law and absolute pressures.

When a rubber bag is used there is a slight elasticity in the bag which will assist the expansion of the gas toward keeping the pressure constant. The ordinary rubber bag for a a gas engine has been reinforced with cloth which prevents any elastic expansion, and consequently for one charge to the engine the bag is practically a solid tank if used alone.

Answer-at-Large.

By H. W. Jones, Sup't., Gas Engine Dept. Peoples Gas Light and Coke Co., Chicago, Ill.

In answer to your favor I want to say that the type of engine must be taken into consideration. For instance, a 20 H. P. Is it a hit and miss, or throttling governor? Is it a single cylinder or a double cylinder; and, again, what load does engine pull, also what is the peak load? Then, what is pressure of gas at meter outlet, and what is distance from meter to engine? The longer the run the bigger the pipe must be and the easier it can be made for the engine to get gas, and the quicker it gets it the better. Also the gas should go into the engine cool.

Now it follows that it is volume that the engine needs, and

pressure and flow to keep bag full. The size of bag cuts no figure in the case at all, so it will give one full charge but the supply pipe must be fully adequate to furnish another charge at once, or when needed. In a hundred horse-power engine, throttling governor, three cylinder, installed in this city there is no gas bag at all and the pressure is cut down to two-tenths pressure at a point 10 feet from engine, when engine is operating there is a constant suction showing on gauge three-tenths inches vacuum. On another we have a tank 24″ x 40″, each being installed by the makers and both throttling engines same size, same load, or practically so. Which is proper? Well, I'll be honest—I don't know.

But, a rubber gas bag is a fraud, a delusion and a snare; an iron tank is better, better for fluctuation or any and everything else, and cheaper, safer, cleaner and put right where it belongs *close* to the engine.

As for fluctuations, the gas is taken away quick irrespective how big the gas bag may be the fluctuation is there just the same, but of course decreases in intensity. The gas tank is as good as a bag in this case.

Question No. 51.

The Bureau has not prepared an official reply to this question, accepting the following answer-at-large as satisfactory.

Answer-at-Large.

By Walton Forstall, Ass't. Engr. of Distribution, Philadelphia, Gas Works.

This question assumes that an answer may be given applicable to "larger cities," stating the exact number of district shops conductive to the most economical distribution work. The reality is that there will be a different solution for each city, for, in addition to the conditions "as to the number of consumers per unit of area, also the size of the city and local characteristics as to growth, etc.," the lay-out of streets, the

existence of water courses and railroad tracks and terminals, acting in the absence of bridges as barriers between adjoining localities, all these and many other conditions peculiarly local will determine the most economical distribution organization. even in a concrete case,—when the question for decision is, shall a given territory be divided into two or more? It is almost impossible to estimate exact operating costs under both sets of conditions. It is often equally difficult to compare actual workings before and after the division was made, for new factors come in to confuse the situation. Horse sense will always have to play a certain part in matters of this kind. Therefore, all that can be attempted is a rather general survey of the points to be considered in deciding the division of distribution work into district shops.

It will be necessary first to define the function of the district shop. In some large cities, each district shop corresponds t a separate distribution district, caring for main, service and meter work. Where this is true, the number of shops will be affected largely by the minimum amount of main work, for in actual operation the transfer of men from one district organization to another is not easily done. With less than 40,000 meters and a main system not having more than an ordinary amount of winter leaks, the district main gang would not have work enough to do during the winter months on days when leaks were few, unless the district was a very growing one and the climate permitted building during the most of the year.

Let it be assumed, however, that the main and service work is independent of the district shop, which serves the consumer solely for inside work. The reasons against separate shops might be increased costs for salaries, rents and all other charges indispensable to separate establishments. The reasons for separate shops might be increased economy and prompter service, due to lessened distance between shop and consumer, being sufficient to offset any increased cost due to separate establishments. Where the geographical center of the community happens to be near the gas works, which has land not

excessive in value, available for a distribution shop and yard, a condition might arise where 100,000 meters and over could be most economically served from one center. As factors in increasing the economic radius of a shop may be mentioned (1) the telephone, (2) the bicycle and (3) the motor wagon. (1) When the usual pay station call is but five cents, a system by which complaint men telephone in for orders several times a day, largely reduces the advantage of nearness possessed by the district shop. (2) The use of bicycle instead of a wagon for all work where little or no material is carried, lessens the cost of each mile traversed. (3) The extensive replacement of horses by motor wagons, due within the next decade, tends toward one garage to replace scattered stables, and reduces the advantages of a district shop existing as a complete unit. Again, for much pipe cutting and threading, often done by hand, power can be profitably substituted if enough work can be provided. This is another argument in favor of concentration.

Separation of costs of operation is one of the advantages of district shops. When working from one shop, it is extremely difficult to ascertain results as between different inspectors or workmen. With more than one shop, by a separation of pay rolls and of material reports, each shop can be compared for each class of work cared for by a separate account. The increased economy obtained by such monthly comparisons may often over-balance increased fixed charges involved in separate establishments. Therefore, a failure to compare costs between shops involves throwing away one of the strongest advantages accruing from district shops.

Where a location, advantageous from the standpoint of distribution work, is also suitable for a new business store, and therefore for bill collection, there is every reason to combine the shop with the store, and this combination by reducing rents and making it easier for consumers to buy appliances and pay bills is an argument in favor of district shops.

In conclusion, it may be said that no change in existing

conditions, either towards combining existing shops or establishing additional ones should be effected without a careful consideration of all the *pros* and *cons*. In general, no subdivision is justified unless the number of consumers served is so large that with a full utilization of all modern space annihilating agencies, the costs after subdivision are less, or if more, nearly equal, and any slight excess is justified by prompter service and expectations of reduced cost owing to comparison possibilities.

Question No. 52.

The Bureau of Informations submits as its answer to this question the experience of Mr. R. M. Searle, of the Rochester Railway and Light Company, which is as follows:—

The Rochester Railway and Light Company are using an electric automobile truck in the Underground Cable Department. This truck is for distributing large reels of cable and also used for pulling same in the conduit system. We find that this truck will pull in more cable in one day than formerly took a team four days to accomplish.

We intend in the near future to supplement this equipment with two more, as the results obtained indicate this electrical truck to be an economical investment.

We have had this particular truck approximately one year, buying the same second-handed and costing $2,400. After running this truck 3,000 miles, the tires are evidentally equal to another year of the same use. We spent $150 for battery renewals and about $50 for other additional repairs. The cost of current is practically our generating cost, as the truck is charged off of the peak.

Cost of truck		$2,400.00
Int. and depreciation, 15%	$ 360.00	
Repairs	200.00	
Charge current at cost	750.00	
		$1,310.00

This amounts to $0.43 a mile.

We have no record of the tonnage carried or the miles of cable pulled in, and consequently data is somewhat unsatisfactory, however, the results obtained are far from being so.

Question No. 53.

Answer by A. H. Elliott, New York.

I have found from large experience that a sixty-inch photometer bar is the best; also the disc which I prefer is a star with twenty-four points on it. I have no use for the circular grease spot, as I find two men cannot read alike with it. I have tried this with a number of my assistants, of which I have sixteen, and have found that the star disc read for definition at the points is much the better to use. You will find two men agree within one-tenth of a candle if you read the points for definition; even when the colors of the lights are very different, such as the Hefner lamp and the Welsbach mantle. I use a piece of calendered paper in which the star is cut out, and on the face of this paper on each side a sheet of nearly white tracing cloth, the whitest that you can buy, is placed under the glass disc.

Question No. 54.

Answer by the Bureau of Information.

In endeavoring to secure a favorable answer to this question the Bureau of Information consulted several prominent men in the new business work of certain gas companies and the concensus of opinion offered was to the effect that in a very large majority of cases, the rental plan of placing arc lamps is successful, in fact, in one of the largest cities in the country there is no incentive for a customer to purchase an arc lamp. In some cases in this city it was found that some customers did not care to use arc lamps, but who had in the past used arc lamps and desired to change to some other style of fixture. These customers were accomodated by having special devices made up such as they required, or such devices were purchased on the open market and installed for them.

Answer-at-Large.

By S. B. Stewart, Genl. Contracting Agent, Philadelphia Co., Pittsburg, Pa.

A straight rental system can never be the ideal system, principally for the reason that the consumer does not give the lamps the care and attention necessary to maintain them at their full efficiency.

No lamp, no matter how well constructed or perfectly adjusted, will remain in good condition unless properly cared for. The average consumer knows very little about the mechanical construction of the lamps and is not properly equipped to give them the attention they require.

The most practical and satisfactory way to handle lamps is to furnish them for the use of the consumer without any rental charge, but with an agreement that a specified sum is to be paid the Company each month for maintenance, in consideration of which, the Company takes care of the lamps and keeps them in good condition.

The Company selling the gas is vitally interested in the efficiency of the lamps, and should therefore, clean, repair and inspect them at regular intervals.

Practically every consumer would be willing to pay a monthly charge for such maintenance for a good, satisfactory light.

Where the Artificial Gas Company has keen competition, especially from cheap natural gas, neither the rental nor the maintenance charge can be made, but even under such circumstances the Company should place lamps and maintain them absolutely free of charge.

If the maintenance department is placed on a good, systematic basis, this maintenance should never exceed thirty (30c.) per month and will often be as low as twenty-two (22c.) cents or twenty-three (23c.) cents.

Even with such free maintenance the Company will find it to be of great advantage to them to handle lamps.

By H. F. Parcher, Mgr., Appliance Store, Springfield Gas Light Company, Springfield, Mass.

Six (6) years ago the Springfield Gas Light Company instituted a system of putting in arc lamps, on a rental system of 60c. per month, which was to pay for a bimonthly inspection and cleaning; also pay Gas Company interest and depreciation on the price of the lamp.

Soon after, when lamps were reduced quite materially in price, this price was changed to 25c. per month.

The system had many objections, one of which was the tendency of the applicant to order his lamps out at the approach of hot weather, which, our experience showed, depreciated the lamp more than three or four years of constant use, and which entailed a considerable amount of breakage of glassware.

Another objection was from the fact that, in some cases, where an installation of 100 or more lamps were made, the applicant did not consider it fair to charge them the same price per lamp as some consumer who used only one or two, and in most cases the user of the lamps would ask for permission to take care of his own, supplying his own mantles and glassware.

The Company soon after numbered their lamps, with progressive numbers, similar to the meter numbers, and commenced putting lamps in without charge, which system has been followed, and is being continued at the present time; the trimmers cleaning the lamps without charge, simply charging for mantles and glassware, where furnished, at a profit of 50 to 100 per cent.

In Springfield we find the last method has proved the most satisfactory of them all, as we continue to hold most of the business during the summer months. If we do not get it all, we at least get a part of the lighting. In the early fall the lamps come into constant use again. The expense of taking them down and hanging them up is entirely done away with,

and the returns, from profit and mantles and glassware, is almost as much as where rental is charged.

The Company has used for several years one make of arc exclusively, although at the commencement several different types were used, and although the lamps have been depreciated several times, there have been none of this one make put into the scrap heap, although some of them have been sent to the factory and have been refinished.

By D. D. Barnum, of the Worcester Gas Light Company, Worcester, Mass.

Our experience with the rental system and maintenance of gas arc lamps has been very satisfactory indeed; it has worked better than any other method we have tried.

The success of gas arc lamps depends almost entirely upon their being properly cared for and if the Gas Company owns and cares for them this can be accomplished, whereas if they are owned by the consumer they are seldom given the care they require.

By Geo. W. Thomson, Mgr. New Business Dept., Suburban Gas Company of Philadelphia, Chester, Pa.

Considering this from the Company's standpoint, and on the same basis as other propositions that is a fair profit on investment.

Now figuring that the Company will put out 500 lamps on the rental plan, which if they stuck (no doubt) will mean a fair profit and ownership of the lamps in five years of the

$500 \times 3 \times 5 =$	$7,500.00
Less cost of lamps	3,000.00
Velvet	$4,500.00

The same on the sales plan would say,

$500 \times 8 =$	$4,000.00
Less cost of lamps	$3,000.00
Profit	$1,000.00

The figure 3 represents rent received for lamp, that is lamps that are rented and maintained at fifty cents per lamp per month, $3.00 of this is credited to maintenance and $3.00 to lamp. The figure 8 is selling price without maintenance.

Space will not allow us to go into the arguments for and against the Sale vs. Rental, but from our standpoint as well as from the customers, we have found the rental to be much the better proposition.

Question No. 55.

Answer by the Bureau of Information.

There is no satisfactory book on American practice in Gas Distribution. There is a very good English book by Walter Hole, entitled, "Distribution of Gas," published by John Allan and Co., London, 1907, in which there is much reference to American practice, and it is in general a very good book of references.

The following papers are suggested as valuable reference papers on this subject:

High Pressure Gas Distribution, J. D. von Maur. Proceedings Amer. Gas Inst., Vol. 3, 1908.

Notes on Mains and Main Laying, Walton Forstall. Proceedings Amer. Gas Light Assn., Vol. 15, 1898.

Consumer's Meters, B. H. Spangenberg. Proceedings Amer. Gas Light Assn., Vol. 21, 1904.

High Pressure Distribution of To-Day, H. L. Rice. Proceedings Amer. Gas Light Assn., Vol. 22, 1905.

Standards Adopted by American Gas Light Assn. for Cast Iron Pipe and Specials. Proceedings Amer. Gas Light Assn., Vol. 22, 1905.

Long Distance Transmission of Gas, W. H. Hammon. Proceedings Ohio Gas Light Assn., 1905.

Instructions for Gas Distribution Employees, J. M. Robb. Proceedings Ohio Gas Light Assn., 1906.

The Compression and Transmission of Gas, E. A. Rix. Proceedings Pacific Coast Gas Assn., 1905.

Cement Joints, J. D. von Maur. Proceedings Western Gas Assn., 1905.

Meter Repair Shop Practice, C. L. Day. Proceedings Ill. Gas Assn., 1908.

Report of Board of Revision on Distribution of Gas. American Gas Institute, 1906.

Description of the Connelly automatic governor, Practical Class Answer. American Gas Light Assn. Proceedings, 1898, page 26.

Street Main Records, by H. E. White. American Gas Light Journal, April 9, 1906.

High Pressure Distribution, by R. M. Searle, Progressive Age, July 1, 1907, page 344.

Paper by E. A. Rix on Pressure Distribution; this is a continuation of the paper given in the list of Messrs Rice and Johnson. Progressive Age, Nov. 15, 1906, page 700.

Electrolysis—Report on, for American Gas Light Assn., Proceedings American Gas Institute, 1906.

American Practice of Gas Piping, by Gerhard.

The standards adopted by the American Gas Light Assn. for cast iron pipe and specials, as given in the American Gas Light Assn. Proceedings for 1905, have since been modified; subsequent proceedings of the Gas Light Assn. or American Gas Institute will show these modifications.

Question No. 56.

Answer by the Bureau of Information.

Replying to the first portion of the question, there are some companies which measure the drip oil collected in the mains, calculate the volume occupied by the hydrocarbon condensate

and by the water, as they existed in the gas in the form of vapor and reduce their "unaccounted for" by this volume.

Let us examine into the accuracy of this:

To get purification results, and to conserve the illuminating value of the gas, it is generally recognized that the gas (water gas particularly) should be purified at a temperature of 90° to 95° F. This allows the gas to be station-metered at a temperature frequently from 85° to 90°, from which it passes to the holder, where it is further cooled, and thence to the mains, where for a considerable portion of the year, it reaches its lowest temperature.

From the point of minimum temperature, the gas begins to expand and, as it is not in contact with water, it does not follow the formula for expansion set forth in the usual tables, which is for saturated gas.

The gas is therefore reduced in volume.

(*a*) By the condensation of hydrocarbon vapors, due to the cooling of the gas from the temperatures at the station meter to the temperature at the outlet of the distribution holder.

(*b*) By the cooling of the water saturated gas from the temperature at the station meter to the temperature at the outlet of the distribution holder. The formula for this reduction is that upon which the usual tables are based.

(*c*) By the condensation of the hydrocarbon vapors, due to the cooling of the gas from the temperature at the outlet of the distribution holder to the minimum temperature reached in the distribution system.

(*d*) By the cooling of the water saturated gas from the temperature of the outlet of the distribution holder to the minimum temperature reached in the distribution system.

There is an increase in volume:—

(*e*) By the reduction in pressure on the gas between that at the station meter and the consumers' meters.

(*f*) By the expansion of the gas from the point of mini-

mum temperature in the mains to the average metering temperature in the consumers' meters. This, being generally out of contact with the water, does not expand according to the formula for a saturated gas, but to the formula for a perfect gas.

This statement of the influences exerted on the volume of the gas from the station meter to the consumers' meters includes only those that vitally affect the final result. A complete study of all the influences is far more complex and depends largely on local conditions. If the distribution holder has a layer of hydrocarbon condensate floating on the surface of the water in the tank, the interaction between this condensate and the hydrocarbon vapors in the gas can only be known in its influence upon the loss of volume of the gas and the dropping out of the hydrocarbon vapors, by a thorough knowledge of the constituents of the two. It is possible, but not at all probable, to actually replace, and more than replace, the entire volume of hydrocarbon vapors condensing out of the gas, by the hydrocarbon vapors passing into the gas from the hydrocarbon liquid on top of the water in the tank. Whenever the gas comes into contact with hydrocarbon condensed out at a lower temperature, there is a tendency to increase the volume of the gas by the passage of some of the condensate back into vapor.

Again, a study of the influences of temperature and the direction of flow of condensate in the mains, would prove to be somewhat complex. A twenty inch main under asphalt in cities, in the vicinity of the parallel of latitude, has a nearly constant temperature at the bottom, but widely varying temperature at top. This results in the winter months in dephlegmating action of the hydrocarbon vapors. The gas, passing along the cool upper portion of the pipe, is cooled and drops some of its hydrocarbon vapors, which falls or flows down to the bottom where, the ground temperature being warmer, some is again vaporized and a heavier condensate is left in the mains than obtains in other seasons.

Under these conditions, the propriety of getting a closer approximation to the "unaccounted for" gas by deducting the volume as vapor of the liquids pumped from the mains is doubtful. The gas, as a rule, suffers changes in volume in the holder, far in excess of those changes in the mains, and the companies correcting for condensation in mains only, taking no cognizance of condensation in holder, are correcting for only one and not the most important class of losses in volume. To actually measure the condensation dropping out in the holder is almost impossible in practice. Frequent readings with hygrometer at holder inlet and outlet would give bases on which reliable calculations could be made.

So far, nothing has been said about complications introduced where correction is made to reduce the observed volume at the station meter to the volume of 60° by the use of the factors set forth in the usual tables. By these factors the reduction due to the condensation of aqueous vapor down to 60° is accounted for. If, then, the gas enters the mains at temperatures above 60°, the water condensing out between "the inlet mains" temperature and 60° will have been accounted for twice:—once for formula and once by measurement of water in mains.

To illustrate the difference in estimating "unaccounted for" gas, let us—

Suppose 1000 cubic feet of water gas is registered on a station meter at a temperature of 90° F. and 10 inches back pressure from holder and rate of flow; and the gas is made from an asphalt base; that it enters the mains at 70° F. is cooled therein to 40° and passes through the consumers' meters at 55° F. and 1½" pressure; that it registers 870 cubic feet on the consumers' meters.

What is the "unaccounted for" gas, figuring—

1st. Correcting the gas to 60° and deducting from the "unaccounted for" gas only that portion collected as liquid from the drips.

2nd. Applying all the corrections set forth in this answer.

1st. Solution.

1000 cu. ft. of gas at 90°=917 cu. ft. at 60°
Consumers' registers .....870 " "
47 " "

Gallons of liquid collected from drips:

Oil = .12 gals. = .9 pds. = 3.6 cu. ft.
Water = .8 " = 16.8 " "
20.4 " "

and taking the difference (47—20.4) we obtain for "unaccounted for" gas .....26.6 cu. ft.

2nd Solution.

At 90° Station Meter ..... 1000.00 cu. ft.
Consumer's registers ..... 870.00 " "
Difference ..... 130.00 " "

	Decrease cu. ft.	Increase cu. ft.	
a. Loss in hydrocarbon vapor cooling in holder from 90° to 70° = 103 gals.	3.09	.....	.....
b. Deduction in volume of saturated gas cooling from 90° to 70°—(10" press)	58.51	.....	.....
c. Loss of hydrocarbon vapor cooling in holder 70° to 40°	3.60	.....	.....
e. Increase in volume due to change from 10" in holder to 1½" in mains, 934.80 increased to 954.43 cu. ft...		19.63	
d. Reduction of 954.43 cu. ft. from 70° to 40° reduced to 885.34 cu. ft.	69.00	.....	.....
f. Expansion to 55° as unsaturated gas to 910.53 an increase of		25.19	
	134.20	44.82	130.00
	44.82	.....	89.38
	89.38	.....	40.62

In 1st solution, not based on accuracy, the unaccounted for gas is $\frac{26.6}{917} = 2.9$ per cent. of station meter registration corrected to 60°.

In 2nd solution, the unaccounted for gas is $\frac{40.62}{1000} = 4.06$ per cent. of meter registration.

If the gas in the first problem had been corrected to 55° the temperature of the consumers' meters, assumed in the example.

1000 cu. ft. at 90°	905 cu. ft. at 55°		
Consumers' registers ...	870 " "		
Difference	35		
Accounted for in drips..	20.4		14.6
	14.6 cu. ft. or		$\frac{14.6}{905} = 1.6\%$

If the average temperature of the gas at the consumers' meters each month could be ascertained and the gas at the station meter could be corrected to this average temperature instead of to 60°, the "unaccounted for" gas would be as close as approximation to what actually occurs as could be had without retort to very careful corrections, involving many, and in actual work, very difficult observations.

From what has been shown the hopelessness of getting in practice exact figures on leakage is obvious. Nor can one company's figures be compared against another where the bald statement of such and such per cent. of leakage is made; the method of computing the leakage must be set forth.

Gas companies usually do not correct for barometric pressure in figuring on "unaccounted for" gas since the average barometer from year to year does not change sufficiently to affect results; but in the larger companies other necessary daily observations and calculations, such as comparisons of make one

day against another, make it essential to correct for barometer.

The above answer applies to the ordinary low pressure district, and applies more or less to high pressure distribution, where the gas is enriched with oils beyond the compression station or stored in outlying holders after compression; even then, it is doubtful if it is advisable to apply much correction as outlined in this answer.

APPENDIX TO PAPER BY ALFRED E. FORSTALL.

Brief History of Gas Legislation in Great Britain and Extracts from Acts Applying the Sliding Scale and Auction Clauses.

The adoption of the Sliding Scale Regulation of Prices and Rates of Dividends in 1875 and the Auction Clauses in 1876 was the last step in the evolution of a system of governmental regulation of the gas business that had been built up gradually in Great Britain, principally as a result of the conditions that slowly developed in this business as carried on in London. When companies were first incorporated for the supply of gas in London it was thought that the automatic action of the principle of competition would furnish a sufficient regulation of prices and profits. Consequently company after company was incorporated between 1812 and 1847 until at the latter date there were ten gas companies operating in London with no restriction as to the price to be charged for gas but with three or four competing for business in every locality, for though each single company was restricted to a certain territory the various districts overlapped to an extent sufficient to bring about the above result. In 1847, however, Parliament placed certain indirect restrictions upon the powers of charge of the companies which were practically the same in each case and identical with those contained in Sections 30 to 38 inclusive of the Gas Works Clauses Act, 1847.

"These restrictions may be summarized as follows:—

1.—The Company shall not declare a dividend of more than 10 per cent. on their paid-up capital, unless a larger dividend is necessary to make up any previous dividend, which has fallen short of 10 per cent., to that amount.

2.—Any profits beyond the sum necessary to pay a dividend of 10 per cent. and make up any previous deficiencies, are to be devoted to forming a reserve fund up to an amount equal to one-tenth of the nominal capital of the Company, for the purpose of making good any deficiency in dividend, or meeting any extraordinary claim or demand, which may at any time arise against the Company. Whenever this fund is reduced below its full amount, it may be made up again.

3.—A certificate from two Justices is required before this fund may be resorted to for meeting an 'extraordinary claim or demand;' but it may be used for making up dividends without any outside supervision or formality.

4.—An annual account of receipts and expenditures is to be sent by the Company to the Clerk of the Peace of the county in which their works are situated. This is open to public inspection.

5.—Any two gas ratepayers within the Company's district may petition the Court of Quarter Sessions to make enquiry into these accounts at the expense of the Company, who are bound under heavy penalties to produce all necessary books and papers; and if the Court is of opinion that the accounts show an excess of profit over the amount necessary to pay the authorized dividend and to keep the reserve fund full, they must make such a reduction in the price of gas as will reduce the profits of the Company to an amount sufficient to pay their full dividend and keep up their reserve fund."

In 1850 two more companies obtained Acts of Parliament authorizing them to distribute gas in London, followed by another in 1854, making 13 in all. In the Acts of two of these companies a limit was set to the price that could be charged, and when some of the older companies came be-

fore Parliament for new Acts between 1854 and 1857 maximum prices were also inserted in these Acts. Thus was begun the first direct regulation of prices.

Active competition between the companies was still ruling, and for some time kept prices and dividends below the maximum allowed. The companies finally tired of this state of things and agreed among themselves to a division of the whole territory into separate districts, one for each company. After this had been done most of the companies increased their prices and were able to increase their dividends and lay by reserve funds. As under existing regulations prices could not be compulsorily reduced until such time as all back dividends had been made up to the rate of 10 per cent. per annum, which time, owing to the great number of years during which dividends much below this rate had been paid, promised to be far in the future, there was much dissatisfaction among the consumers and an agitation was started for the establishing of a more definite regulation of the monopoly of supply that existed and was accepted as inevitable. This agitation led to the passage of the Metropolis Gas Act in 1860.

This confirmed the districting adopted by the companies, and provided further, that the deficient back dividends which the Gas-Works Clauses Act authorized the companies to make up should be limited to such as had occurred during the preceding six years, and that the maximum price for common gas (as distinguished from cannel gas) of 12 candle-power should be 4s. 6d. per 1,000 cu. ft., with permission to raise this price to 5s. 6d. if necessary owing to an increase in cost of production. It also placed limits upon the amounts of impurities to be allowed and provided for the testing of the gas as to illuminating power and purity by examiners appointed by local authority and gave the Secretary of State general powers of supervision of the operation of the companies.

But this also proved an unsatisfactory solution of the problem. The prices allowed were too high, and while the best

managed companies soon reduced their prices below the maximum, other companies which had been selling at a lower rate raised at once to the maximum and held there, and there was great discontent among the consumers, who claimed that the regulations of the Act put a premium on extravagance and bad management. A Parliamentary Committee appointed in 1866 recommended that the Government should introduce a Bill to alter the law. Such a Bill was introduced in 1867, but not passed, the Committee to which it, with other Gas Bills, was referred being unable to reach a settlement with the gas companies and unwilling to force terms upon them. A special report was made which "whilst it confirmed the complaints of the consumers intimated that the terms made with the gas companies in 1860 ought not to be compulsorily altered except under the threat and pressure of renewed competition." In 1868 a competing Bill was introduced by the Corporation of London which, with other Bills introduced by consumers and the principal gas companies, was referred to a Committee. This Committee after hearing evidence, passed a Bill which was limited in its operation to that part of London known as the "City," since the companies operating in that part were the only ones that had agreed to submit to it.

This Act, known as the City of London Gas Act, 1868, provided for a maximum 10 per cent. dividend as before, the formation of an Insurance Fund, put the accounts of the companies under the control of the Board of Trade by clauses relating to Auditing, and fixed the maximum price at 4s. per 1,000 cu. ft. of 14-candle gas until Jan. 1, 1870, after which it was to be 3s. 9d. for 16-candle gas. In addition provision was made for changing the maximum price at the beginning of any year by giving to any company, or the Corporation of London as representing the consumers, the right to apply to the Board of Trade in January of any year for a revision of the scale of price and illuminating power. In the case of such application the Board was to appoint three commissioners with authority to make an examination and fix such a price

as should be calculated, with due care and management, to yield to the companies a dividend of 10 per cent., such price not to exceed, however, the extreme price fixed in the Act of 1860. The Act also provided new and elaborate machinery for testing the illuminating power and purity of the gas, and provided for the amalgamation of the Companies subject to the approval of the Board of Trade.

The provisions of this Act were soon after extended with a few alterations to other London Companies, and still other companies were brought under its operation by amalgamation. At first it seemed to work well, but when the Gas Light and Coke Company secured an increase of price to 4s. 4d. in 1873 and to 5s. in 1874, and the Imperial Company also secured an increase to 4s. 8d. for 14-candle gas in 1874, in spite of the fact that the working results of the Gas Light and Coke Company compared unfavorably with those of other companies, and that the South Metropolitan with a maximum price of 3s. 6d. for 14-candle gas was able to get through the same period of high prices for coal without any increase, the consumers complained that the real effect of the Revision Clauses was to guarantee to the companies a dividend of 10 per cent. and "that no official commissioners could succeed in dictating to a trading company the conditions of economy of manufacture on which they can make the greatest amount of profit, and in fixing the price of their article accordingly." Complaint was also made that the privilege of issuing new capital to the existing stockholders at par when such stock commanded a large premium in the open market, resulted in putting into the pockets of the stockholders a large amount of money for which the consumers received no return, and also offered great inducements to extravagance in issuing new stock on which the consumers had to pay dividends.

Again some change seemed necessary and an endeavor was made to find a system under which it would be to the interest of the companies themselves to reduce the price of gas. Such a system appeared to be offered by a sliding scale

which would make the dividends depend upon the price charged and vary inversely with it. A sliding scale unlimited in either direction would be fair to each side, but the prejudice against the high rates of dividends that might be paid under such a scale, induced the Corporation of London and the Metropolitan Board of Works to promote, in 1875, a Bill which was to apply to all Metropolitan Companies and provided that at or under a price of 3s. 9d. per 1,000 cu. ft. a dividend of 10 per cent. could be paid, but if the price was raised above this point the rate of dividend was to be reduced ¼ per cent. for each penny or part of a penny of such increase. This Bill was referred to a Committee of the House of Commons, to the Chairman of which was sent a letter from the Board of Trade giving the views of the Government on the Bill and the matter of gas legislation in general. In this letter it was stated that the preceding legislation gave the companies, in the absence of competition, the right to maintain a price, up to the maximum fixed in 1860, sufficient to produce a dividend of 10 per cent. and that the object of the legislation had been to insure that the price actually charged should be the proper one, neither too high nor too low, to produce this dividend. To fix the price at 3s. 9d. with no power to raise it except on condition of reducing the dividend would be a breach of contract. But a sliding scale in which the price should vary inversely as the dividend would seem a more effectual mode of securing "due care and management" than the method of revision than in force. "To make a scheme of a sliding-scale of price and dividend just and effectual, the following conditions appear to be necessary:—

(1) That the initial price and quality of gas shall be fairly fixed, having regard both to the immediate existing interests of the Companies and the Consumers, and to the prospects of both under the new system.

(2) That the price and dividend shall vary in certain fixed proportions without limit; so that, on the one hand the price may be raised without limit as the dividend diminishes.

and so that the dividend may be increased without limit as the price diminishes. Such a plan, if practicable, would be beneficial to the Companies, for it would protect them against the contingency of such an increase of expense in manufacture as would make the price of 1860 insufficient to produce the requisite dividend, and would enable them to share with the consumer any amount of profit that may arise from diminution in expense of manufacture or increased consumption. It would be beneficial to the consumer, because it would, without immediate increase of price, give to the Companies, who alone possess the requisite knowledge and power, a strong interest to reduce expenditure, whether of capital or income, in lieu of the present system under which they have an interest in increasing the expenditure of capital, and no interest in keeping down the expenditure of income."

Such a sliding scale was finally adopted by the Committee and though the Commercial Company was the only one that accepted it, in 1875, the other Metropolitan companies consented to it later, and the principle has been extended until now the majority of the statutory companies in Great Britain are working under it.

The following extracts from the Commercial Gas Act of 1875, (the Commercial Company is one of the three so-called Metropolitan Gas Companies) explains the method according to which the rate of dividend is varied with change in price of gas, together with that by which the insurance and reserve funds are formed, and also the limitation of the amount of the insurance fund and the purposes for which these funds can be used.

"The standard price to be charged by the Commercial Company for gas supplied by them shall be three shillings and nine pence per one thousand cubic feet, provided that the company may increase or diminish such standard price subject to a decrease or increase in the standard rates of dividend as defined by this act to be calculated as follows:—

For every penny or part of a penny charged in excess or in diminution of such standard price in any year the standard

rates of dividend shall for such year be reduced or increased by five shillings in the hundred pounds per annum." (This equals one-quarter of 1 per cent.)

"If the clear profits of the undertaking of the Commercial Company in any year amount to a larger sum than is sufficient to make up the rates of dividend by this act authorized the excess beyond the sum necessary for such purpose shall from time to time to the extent of one pound per centum per annum upon the paid-up capital of the Company be invested in Government or other securities and the dividends and interest arising from such securities shall also be invested in the same or like securities in order that the same may accumulate at compound interest, until the fund so formed amounts to a sum equal to one-twentieth of the paid-up capital of the Company, which sum shall form an insurance fund to meet any extraordinary claim or demand which may at any time arise against the company from accident, which, in the opinion of the auditor, due prudence and management could not have prevented, and if such fund be at any time reduced, it may thereafter be again made up to the said sum, and so from time to time as often as such reduction shall happen, provided that, when, and so often as the said fund shall reach one-twentieth part of the paid-up capital the interest thereon shall be carried to the credit of the fund available for dividend. Provided also that resort may from time to time be had to the insurance fund to meet any extraordinary claim or demand as aforesaid, although such fund may not at the time have reached or may have been reduced below the full amount of one-twentieth as aforesaid.

If the clear profits of the undertaking of the Commercial Company in any year amount to a larger sum than is sufficient to make up the rates of dividend by this Act respectively authorized, and to form or make up the insurance fund by this Act authorized, the excess shall (subject to the provisions of this Act respecting the reserve fund) be carried to the credit of the divisible profits of such undertaking for the next following year.

Where in any year the amount of the prescribed rates of dividend of the Commercial Company shall by reason of a diminution of the standard price charged by the company in such year be increased, then out of the amount of the divisible profits of the company applicable to the payment of such increase the company may in such year set apart such sum as they shall think fit.

All sums (if any) so set apart by the Commercial Company, and the reserved fund existing at the time of the commencement of this Act may be invested in Government or other securities, and the dividends and interest arising from such securities may also be invested in the same or like securities in order that the same may accumulate at compound interest, and the fund so formed shall be called the 'Reserve Fund,' and shall be applicable to the payment of dividend in any year in which the clear profits of the company shall not be sufficient to enable the company in such year to pay the rates of dividend respectively authorized by this Act, and save as in this Act otherwise provided no sum shall in any year be carried by the company to any reserve fund.

There shall be an Auditor of the Accounts of the Companies, being a competent and impartial person, from time to time appointed by and removable by the Board of Trade.

The Auditor shall with all practicable speed after the passing of this Act investigate the accounts of the Companies, and ascertain and certify the amounts of their capitals, distinguishing share from loan capital, and shall from time to time as new capital shall be expended in like manner ascertain and certify the fair amount of such new capital.

The Auditor shall from time to time prescribe a uniform form of accounts to be kept by the Companies.

The Auditor shall half-yearly audit the accounts of the companies, and if he finds the same correct he shall certify the same respectively, but if in any instance he finds the accounts incorrect in principle or in detail he shall require the company to correct the same in such manner as he thinks right, and a dividend shall not in any case be declared until the accounts

are certified by the auditor; and the accounts as certified shall be laid before both Houses of Parliament.

Each company shall give to the Auditor, his clerks and assistants, access to the books and documents of the Company, and shall, when required, furnish to him and them all vouchers and information requisite for the purposes of the audit, and shall afford to him and them all facilities for the proper execution of his and their duty.

If any company think themselves aggrieved by any act or determination of the Auditor, the matter in difference shall be referred to the determination of an Arbitrator agreed on between the Company and the Auditor, or, in default of agreement, appointed on the application of either party, by the Lord Chief Justice of the Court of Common Pleas; and the reference shall be subject and according to the provisions of the Common Law Procedure Act, 1854; and the decision of the Arbitrator shall be final and conclusive; and, subject to this provision, the Companies shall observe and abide by the directions and determinations of the auditor." The Government Department known as the Board of Trade, besides having charge of the auditing of the accounts, prescribe the form in which they shall be kept and receive and publish returns from all statutory gas companies and all Corporations or Municipalities owning and operating gas works.

In combination with the Sliding Scale the Auction Clauses have been inserted in the Gas Acts passed since 1876. These clauses are practically as follows:—

"Notwithstanding anything in this Act contained, the company shall, when any shares of stock created under the powers of this Act are to be issued, and before offering the same to the holder of any other shares or stock in the company, and whether the ordinary shares or ordinary stock of the company are or is not at a premium, offer the same for sale by public auction or by tender within the metropolis in such manner, at such times, and subject to such conditions of sale as the company shall from time to time determine; pro-

vided that at any such sale the reserve price put upon such share or stock shall not be less than the nominal amount thereof, and notice of the amount of such reserved price shall be sent by the company in a sealed letter to the Board of Trade not less than twenty-four hours before the day of auction, or the last day for the reception of tenders, as the case may be, and such letter may be opened after such day of auction, or last day for reception of tenders and not sooner; and provided that no priority of tender shall be allowed to any holder of shares or stock in the company.

The intention to sell any such shares or stock by auction or by tender shall be communicated in writing to the town clerk of the City of London, the clerk to the Metropolitan Board of Works, and to the Secretary of the Committee of the London Stock Exchange, at least twenty-eight days before the day of auction, or the last day for the reception of tenders, as the case may be, and notice of such intention shall be duly advertised four times during the same period in two or two or more London newspapers.

"When any shares or stock created under the powers of this Act have been offered for sale by auction or by tender, and not sold, the same shall be offered at the reserved price put upon the same respectively for the purpose of sale by auction or tender to the holders of the ordinary shares or ordinary stock of the company in manner provided by the Companies' Clauses Act, 1863: provided always that any shares or stock so offered and not accepted within the time prescribed by the said Act shall again be offered for sale by public auction or by tender in the manner and subject to the provisions of this Act with respect to the sale of shares and stock created under the powers of this Act.

Any sum of money which shall arise from the issue of any such shares or stock by way of premium, after deducting therefrom the expenses of and incident to such issue, shall not be considered as profits of the company, but shall be expended in extending or improving the works of the company or in

paying off money borrowed or owing on mortgage by the company, and shall not be considered as part of the capital of the company entitled to dividend."

Much information on the subject of the operation of the Sliding Scale and the details of Acts by which it is applied to the various gas companies can be obtained from a book by Michael & Will, entitled, "The Law Relating to Gas, Water and Electric Lighting;" from a book entitled, "Powers of Charge of the Metropolitan Gas Companies," by L. W. S. Rostron; from the Report of the Select Committee of the House of Commons on "The Metropolitan Gas Companies, 1899," published as a blue book by the British Government, and from the files of the Journal of Gas Lighting, Etc., which, under the heading of "Parliamentary Intelligence," published almost verbatim reports of the proceedings connected with Gas Bills before the Private Bill Committees of the two Houses of Parliament.

The only company in the United States subject to sliding scale legislation is the Boston (Mass.) Consolidated Gas Company, and the Act relating to it will be found in Appendix C of the Report of the Board of Gas and Electric Light Commissioners of Massachusetts for the calendar year 1906 (published in 1907), beginning at page clxxxvi.

WRINKLES—1909.

PREPARED FOR THE FOURTH ANNUAL MEETING OF THE AMERICAN GAS INSTITUTE, OCTOBER, 1909, BY F. L. CROSS, EDITOR.

USE OF AN ECONOMIZER WITH COAL GAS BENCHES.

An economizer of standard make placed on by-pass of the flue connection between the benches and the chimney does not reduce the draught appreciably, in fact the damper is only slightly closed. The feed water used in the boilers is heated by the ordinary feed water heater to 180° and takes up an-

other 100° in the economizer. The apparatus worked well and will probably pay for itself in two years.

CHAS. F. PRITCHARD,
Vice Pres. & Genl. Mgr., Lynn Gas & Electric Co.

METHOD OF SCURFING RETORTS.

In connection with scurfing retorts, it is desirable that the scurfing be accomplished rapidly and the temperature in the retort kept down at the same time. In connection with a recent patent for making CO, or carbon monoxide gas by means of mixing limestone and carbon, it had occurred to me, that if limestone be thrown into the retort which it is desired to scurf, the following action will take place. The limestone begins to give off CO_2 at a reasonably low temperature. This CO_2, or part of it, on coming in contact with the carbon deposited in the retort will be reduced to CO. In that way the retort will be decarbonized.

Inasmuch as the reduction of CO_2 to CO is an endothermic reaction, it will tend to keep down the temperature of the retort during the scurfing process. Care must be used not to carry this process too far, or it will take all the carbon out of the pores of the retort, causing it to leak badly until the pores are again filled up. CO_2 from any source could be used, and the process accelerated by air blast or other means. Naturally all due precautions must be observed during the handling of this process such as to prevent excessive circulation of air in retorts, etc.

WM. A. BAEHR,
Consulting Engineer, Chicago.

REMOVING AN OLD GAS HOLDER.

A 3-lift relief holder was removed to place a new one in the following way:—

The holder was landed and manholes in crown removed. An old exhauster was connected to the top of the stand-pipe on the

Ill. No. 1.

outside of the tank and air was blown in to flush out the gas remaining in the crown. The goose-necks on the outer sec-

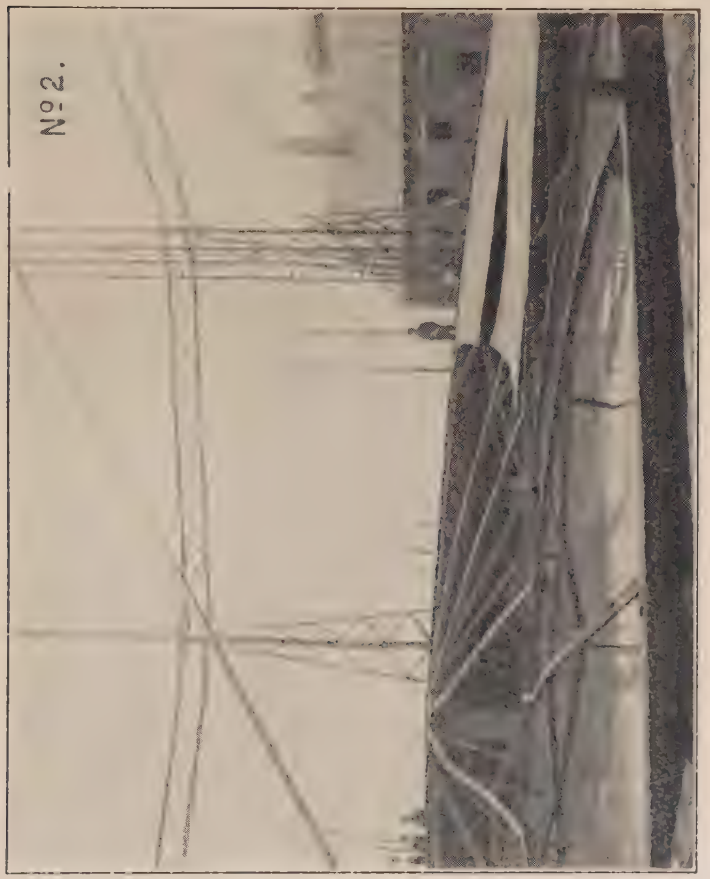
tion were removed and iron straps in the shape of an inverted stirrup were hung on the goose-necks of the middle section and bolted to the outer section where the removed goose-necks had been. (See illustration No. 1, upper left hand corner.)

Manhole covers were then replaced on crown and air pumped into holder until the required height above the tank coping was reached for convenience to the men who stood on the coping to do the work. Iron was then cut below grip channel and down each edge of vertical leg (See Ill. 1 at A) and parallel with grip three sheets lower. Block and falls being hung from girder and guide frame and attached to the sheet to be cut; with hooks, and landed when cut on coping, iron then to be hauled away. As the cutting progressed, the holder was raised and after all the sheet iron had been removed from this section, the curb angle sheet was spiked to blocks of wood placed in the cup (See Ill. No. 2) opposite each tank roller, thus having the use of these to guide the other two sections when lowering (Note No. 1).

The strap verticals were then cut off at the bottom from angle sheets, holder lowered and then cut loose from grip and hoisted out with block and falls. The grip (See Ill. No. 1 at B) was then removed as well as straps and goose-necks of middle section. The inner section was then landed and the middle section hung to the inner section over goose-necks, and cutting off the iron on middle section proceeded as described for the outer section; the goose-necks and rollers on inner or top section and tank rollers of outer section guiding the holder.

After the sheets had been removed from the middle section, the lower angle of outer section and cup of middle section were removed. The inner section was again lowered and held in place by four blocks and falls attached to frame work, just above first girders, and before landing the grip was removed, belonging to the middle section. The inner section after land-

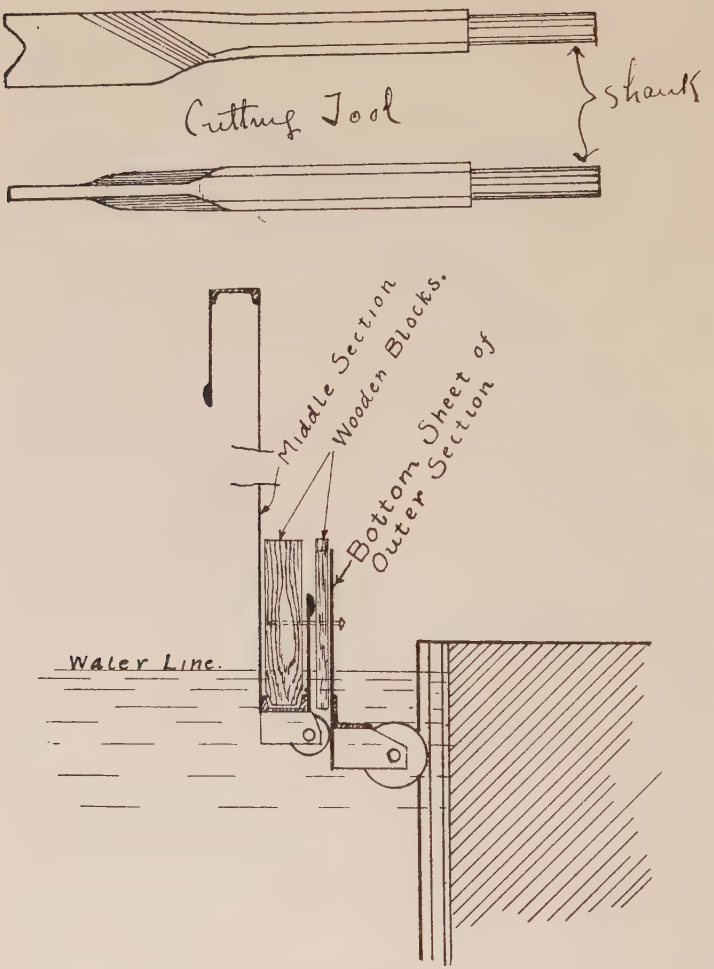
ing was cut out in the tank, (Note No. 2) the crown sheet being removed first, the side sheets next, then the trusses, curb



Ill. No. 1A.

angle of crown, verticles, and last the cup; all iron below tank curbing had to be hoisted out from the tank. The water in the tank was pumped out as work proceeded on inner section, rafts or swinging scaffolds being used to support the men. The cutting was done with pneumatic hammers and cutting tools.

(See Ill. No. 2) excepting extra heavy iron, angles, etc., on these we cut the rivets.



Ill. No. 2.

A Westinghouse pump attached to a small receiver fur-

nished the air, and the pipe laid on curb from tank with air hose furnished the air to hammer in the ordinary way.

The sections of the holder averaged 88′ in diameter, and 25′ in height, and 90 to 100 tons of iron were removed. The work required 21 days, using only two cutters and including cleaning out the tank. The results were satisfactory, as the holder had time to be thoroughly ventilated, as well as the tank with the air used to inflate the holder. There were no complaints from the men recorded at any time during the operation.

Note No. 1.—Illustration No. 1 shows outside section hung on middle section with sheet iron removed; and grip channel vertical legs and angle sheets just above the tank level; and tank rollers attached to lower curb angle below tank level (not shown). Two men are holding pneumatic hammer.

Note No. 2.—Illustration No. 2 shows inner section landed and cutting off the iron of the crown with rafters and king post in place and water pumped out a few feet.

V. L. Elbert,
St. Paul Gas Light Co.

Ill. Nos 1, 1A, and 2.

AN INEXPENSIVE PROCESS OF WATER INFILTRATION.

One of the sources of our gas works water supply is from a river nearby. Water being a rather scarce and very necessary article, we are obliged to use water from the river. After passing it through our circulating system, we return it to the river.

As we all know, circulating water in a gas works, after being used, carries more or less fine carbon particles, light tar, and dead oils. In order to return this water, after using it, to the river in clear and sparkling condition, we devised a system of seepage pits, consisting of a shallow basin dug on

the river bank, in the sand, constructing in these basins a complete, bored, skimming system; our object being to free the water, after being used, of the fine carbon particles, light tar, dead oils, etc. We then diverted our river water overflow from going directly into the river, so as to pass through this series of infiltration pits first, the sandy soil allowing seepage and the skimming system holding any particles of foreign matter that might still be contained in the water.

After constructing these basins and placing the board skimmers in place on the pits, we turned our overflow through with results that were more than satisfactory, and returned the water to the river perfectly free of any foreign matter, and clear and sparkling.

We found that the water was materially reduced in temperature, so much so that we were enabled to use the overflow from these pits over and over again through our circulating system.

The overflow water is contained in a flume and emptied into the suction pit of the river pump.

F. C. Millard,

Supt., Gas Mfg., Los Angeles Gas & Electric Co.

METER FOR REGISTERING STROKES OF PUMP.

Take an ordinary Worthington oil meter dial and place on the pump above the piston rod and far enough to one side so the arm on the piston rod will not strike it. On the arm of the piston rod, place a cleat so that a lever may be attached thereto, connecting the other end with the working arm of the meter dial, (which the plunger ordinarily strikes) so that at every stroke of the piston the arm of the meter dial will be pushed just enough to catch a cog, thus turning the gallon hand on the dial one point at every stroke. If the readings of the meter are taken regularly, you can readily ascertain how many

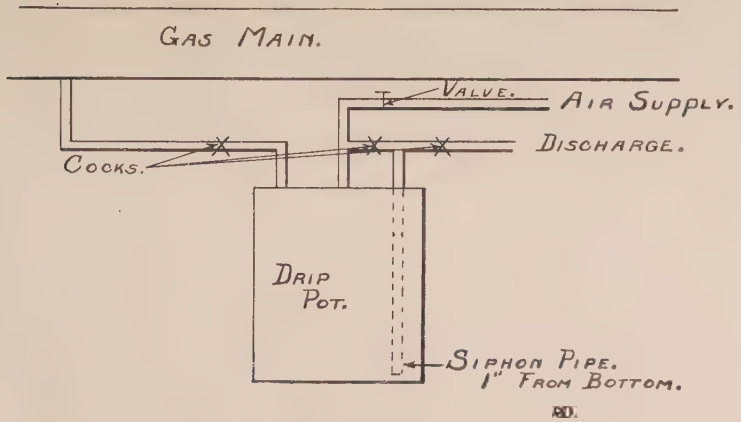
strokes were made during the 24 hours, and thence arrive at the strokes per hour or minute, just as you wish.

The gallons of oil pumped may be obtained by finding how much oil is pumped at a stroke and multiplying by the number of strokes or, in case of a duplex pump, multiply by twice the number of strokes.

F. C. MILLARD,
Supt., Gas Mfg., Los Angeles Gas & Electric Co.

ARRANGEMENT FOR PUMPING DRIPS AROUND WORKS.

The sketch shows an arrangement for pumping drips



Ill. No. 3.

around the works. While the pot is filling the air supply and discharge are shut and the pipe to the gas main is open. When it is desired to empty the drip pot, communication with the gas main is closed, the discharge is opened, and air is admitted. When the drippage is discharged, the air is shut off and any remaining pressure vented through the cock between the air line and the discharge line. Then the discharge is closed and the cock to the gas main opened.

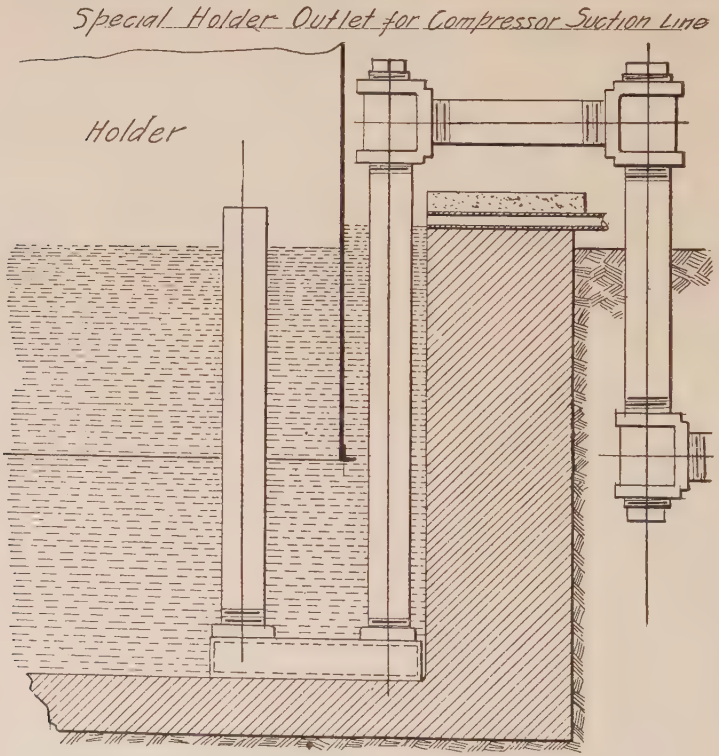
This arrangement is applicable, wherever compressed air is handy. It saves a great deal of time in pumping large drips.

A. F. Traver,
Supt., Gas Dept., Denver Gas & Electric Co.

Ill. No. 3.

SPECIAL HOLDER OUTLET.

The special holder outlet was designed for the suction line



Ill. No. 4.

to the compressor supplying a high-pressure belt line, as we found in taking this suction line out of the regular holder outlet that it cut the pressure to the street too much, it being

only an 8" line, and in a small plant you are taking too many chances of variations in quality of gas to feed a compressor from the holder inlet line.

This is all made up of standard 6" pipe and fittings except the bottom of the U, which is a rectangular casting flat enough to clear the bottom curb of the holder when grounded, and of sufficiently larger sectional area to care for some drippage in addition to supplying the 6" pipes. The U was made up and lowered with a block and tackle from the guide frame and tipped sufficiently to turn under the curb when the holder was up to the blowing point, and after being placed was anchored with a couple of band irons in addition to the pipe connections into the ground. With the rigid connection at the top and the heavy foot casting, we find no perceptible tendency toward flotation.

Both of these devices are in successful use at Adrain.

R. Shacklette,

Mgr., Adrian Gas Co., Adrian, Mich.

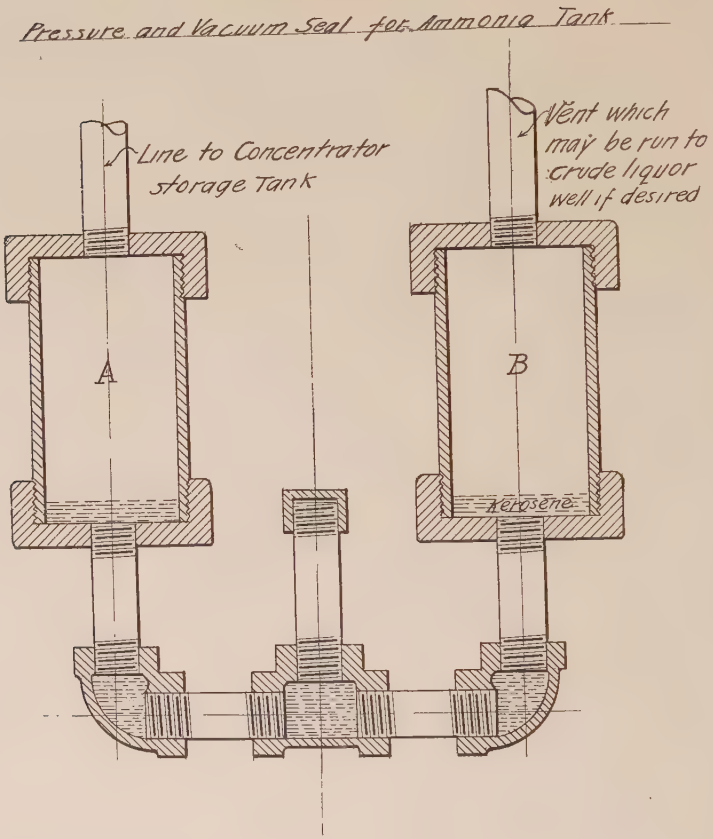
Ill. No. 4.

PRESSURE AND VACUUM SEAL FOR AMMONIA TANK.

The pressure and vacuum seal for ammonia tank was designed as a cheap substitute for a pair of pressure and vacuum valves and can be made by any fitter from standard pipe fittings. This can be set on top of the ammonia storage tank with the line to the Receiver A connected to it, and the other one venting to the atmosphere, as it is scarcely worth while to return it to the liquor well.

The Receivers A and B must each be large enough to contain all of the kerosene or other fluid contained in the piping below the filling line, in the event of the pressure or vacuum being sufficient to break the seal. By increasing the length of

the receivers A and B and the filler pipe, they can be made


Pressure and Vacuum Seal for Ammonia Tank
Line to Concentrator storage Tank
Vent which may be run to crude liquor well if desired
A
B
Kerosene

Ill. No. 5.

to carry any pressure and vacuum desired before breaking the seal.

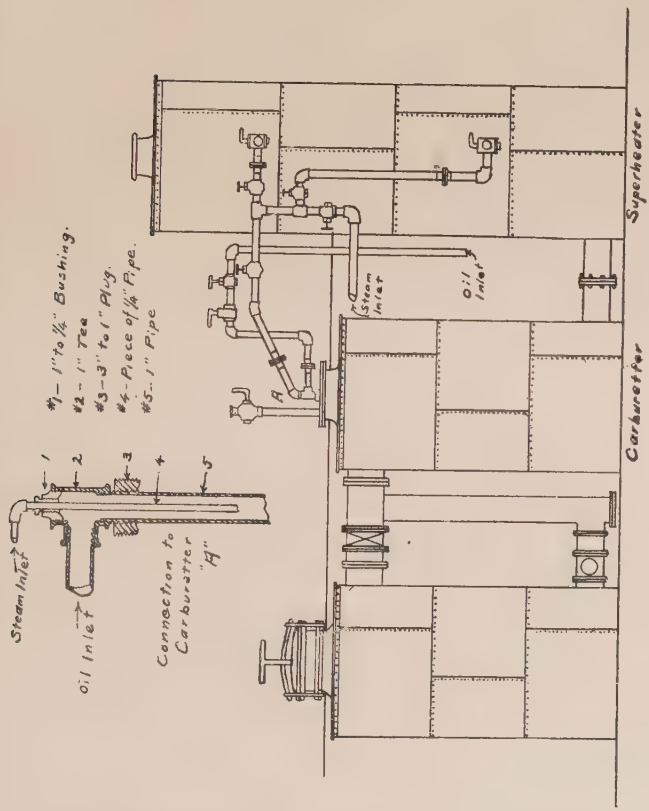
R. SHACKLETTE,

Mgr., Adrian Gas Co., Adrian, Mich.

Ill. No. 5.

TO PREVENT LAMPBLACK IN THE TAKE-OFF PIPE IN A WATER GAS MACHINE.

The accompanying sketch shows a method we have used to



overcome the making of lampblack, and which also, we think, has slightly increased the make per run.

We have had this in use over two years and have had no trouble with the drip-pipe in the wash-box, or with the take-off pipe stopping up with lampblack.

There is a steam connection in the top of the carburetter through which we turn the steam on half a minute before the oil is turned on to reduce the extreme heat in the top of the carburetter.

The oil is then turned on and the steam used to spray the oil. At the same time a little steam is turned in the lower sight-cock of the superheater and left on during the entire run.

While blowing up on the last run of the day, we use steam for two minutes in the upper and lower sight-cocks of the superheater, to keep the checker-brick clean.

CHAS. A. ROBERTS,
JOHN MCDONALD,
New London Gas & Electric Co., New London, Conn.

Ill. No. 6.

AUTOMATIC CONTROL FOR WATER GAS EXHAUSTER.

This consists of a butterfly valve placed in the steam line to exhauster engine, placed about 4 feet above the globe valve on steam line. To handle this butterfly valve a steel wire, run on suitable pulleys, leads to the fastenings on top of the relief holder, the wire is so arranged that when the relief holder is down to a certain point the butterfly valve is closed, shutting off the exhauster. This arrangement was used at a water gas plant to prevent the relief holder crown from being drawn in.

E. C. WHITE,
Western Gas Construction Co., Fort Wayne, Ind.

FILTERING TAR FOR BURNING UNDER BOILERS.

By passing the tar through 16 thicknesses of wire cloth, having a No. 14 mesh and made of No. 20 wire, we have eliminated all particles of ash and lampblack from the tar which would stop up the burners. We then spray the tar into the fire-box by means of a steam jet tar burner. We have found that tar burned in this manner is more valuable

as boiler fuel than crude oil. We pump our tar through a pipe, which reaches to within 6" of the bottom of the relief holder (used as a storage tank) and on the bottom of this pipe a flange is screwed so that we always get the heaviest tar and the tar with the least amount of water in it. By filtering the tar as above, we find that we can burn it satisfactorily, even though it does contain a high percentage of water.

M. J. Dewey,
San Antonio Gas Co.

NAPHTHALENE WASHER.

Water gas made from Indian Territory oil contains considerable naphthalene. In order to determine if we might use this crude oil to wash the gas, we made the following laboratory experiments.

Determined that crude Indian Territory specific gravity 28° B., sulphur .26% will absorb about twice as much naphthalene as water gas tar made from the same oil.

Determined that hydrogen passed through the oil collected 12 to 28 grains of organic sulphur per 100 feet, but did not collect any H_2S.

Determined that water gas containing 40 to 50 grains of organic sulphur on being passed through the oil loses about 25% of its organic sulphur, and collects no H_2S.

We have, therefore, concluded to use oil for washing our gas.

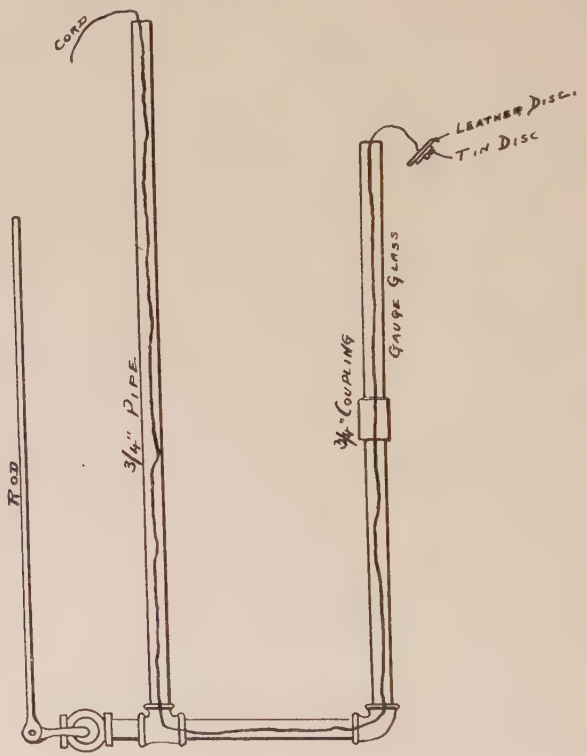
A naphthalene washer using crude Indian Territory oil is now in use in Galveston, Texas, and is giving good results.

A. H. Calkins,
L. B. Moorehouse.

METHOD OF DETERMINING DEPTH OF OIL ON TOP OF HOLDER TANKS.

With holder close to blowing point, lower thief into water,

turn glass end in under the shell; then very slowly raise thief, keeping it plumb, until top of glass is above inside water level;



THIEF FOR MEASURING OIL ON SURFACE OF WATER IN STORAGE HOLDER.

S. K. CAMPBELL.

HEMPSTEAD, N. Y.

Ill. No. 7.

close cock by means of rod, close inside end by pulling on cord, and remove thief. Depth of oil will be shown on water in glass.

S. K. CAMPBELL,
Genl. Supt., Nassau & Suffolk Lighting Co.

Ill. No. 7.

INCREASING RECORD ON RECORDING PRESSURE REGISTER.

Having in use a recording pressure register used for registering pressure on city mains at the gas works, the height of holder or float being about 18" and diameter 12" registering up to 50/10ths pressure, as per chart spaced and marked No. 1, and wishing to record a higher pressure on the same spacing of sheet, I placed a lead weight on top of the holder or float (the quantity must be determined by trial) until the proper weight of metal produced the desired range and then changed the scale reading on chart to suit.

Chart No. 1 records from 0" to 5" pressure.

Chart No. 2 after weighting float records from 1" to 6" pressure.

As our minimum pressure is not less than 2", the 1" loss on chart at bottom is of no use as a record and is added at top of sheet as stated.

Any recording pressure register can be altered in this way to record pressure desired, and save purchasing a new one.

V. E. Elbert,

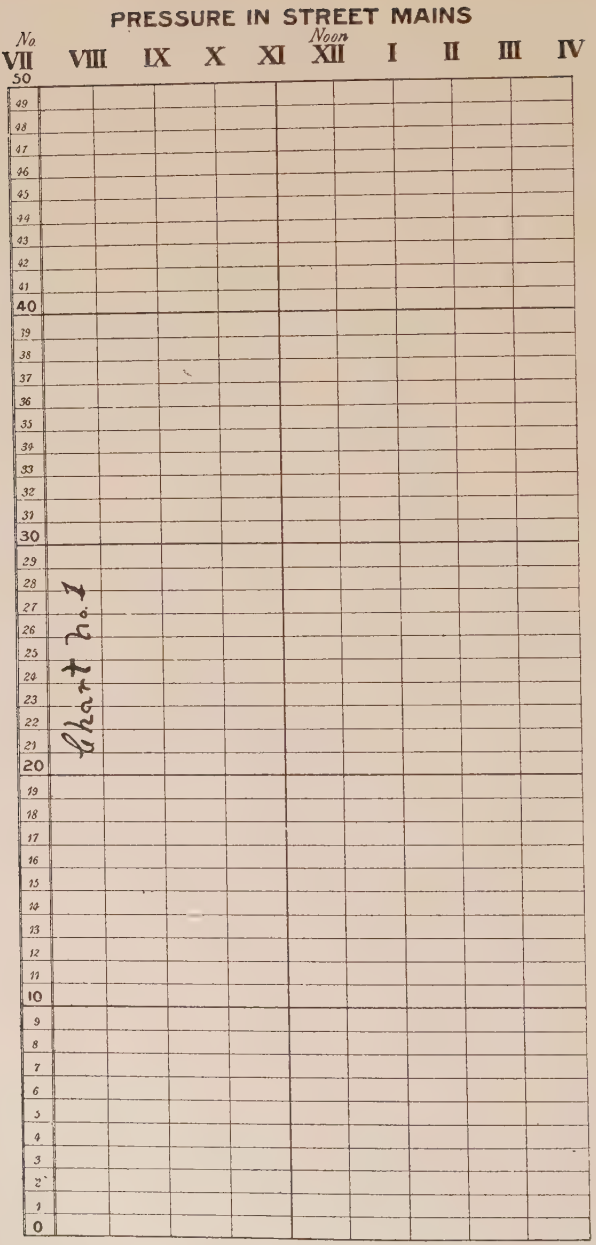
Supt., Gas Works, St. Paul Gas Light Co.

Ill. Nos. 8 and 8A.

PLACING LANDING BLOCKS UNDER AN OLD GAS HOLDER.

Wishing to raise the inside section of an old gas holder to place sixteen new landing stones as well as raise center pier an equal height, holder having been let down to place in a larger and additional inlet pipe, I adopted the following way:—

The holder and tank had been thoroughly ventilated and


PRESSURE IN STREET MAINS
No
VII
VIII
IX
X
XI
Noon
XII
I
II
III
IV
50
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47
46
45
44
43
42
41
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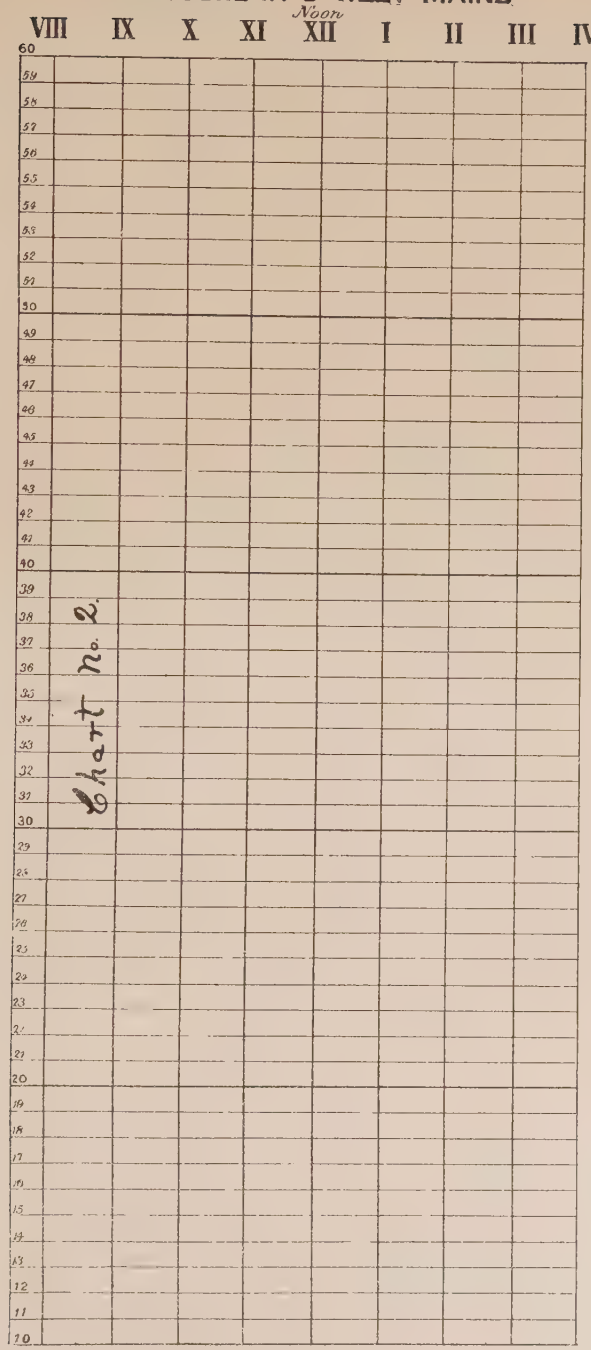
Chart No. 1

Ill. No. 8.

PRESSURE IN STREET MAINS



Ill. No. 8A.

after work had been completed on the new inlet pipe, water to the depth of one foot was run into the tank.

Three men entered through the manhole and a manhole cover of wood, with a heavy light of glass was placed on the opening and bolted down in place of the regular manhole cover.

A three-quarter inch hose was connected to the crown sheet on the under side, to a three-quarter inch pipe nipple through the sheet and a hose with a valve attached to the same nipple on the outside of the crown sheet, which answered as a speaking tube which communicated with men inside.

Air was then pumped into the holder with a small plunger air pump, connected to a three-inch flange to the crown of the holder and when the holder was proper height the landing stones were placed on beds of dry concrete mortar and levelled from the water level in the pit.

The glass in manhole furnished enough light to get around in the pit, electric flashlights being used to furnish light to do the work.

The job was all completed in three and one-half hours from the time the men entered, to their exit from the holder, with no evil effects whatever.

The glass cover could have been broken for the quick release of the men had they so desired.

V. L. Elbert,
Supt., Gas Works, St. Paul Gas Light Co.

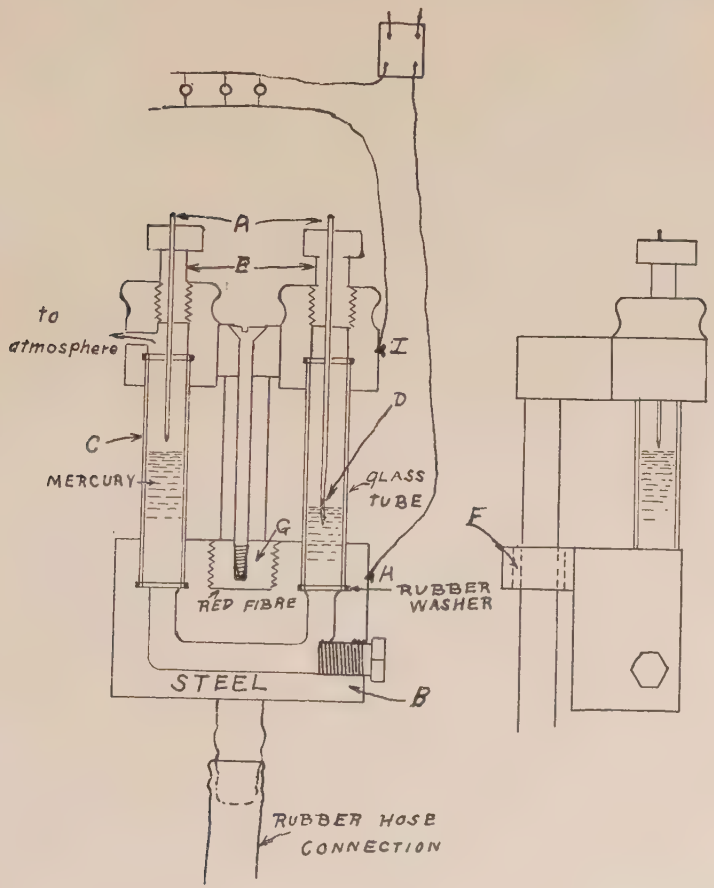
PRESSURE ALARM.

The accompanying sketch shows a maximum and minimum pressure indicator.

The device is a modification of the ordinary pressure gauge in which the bottom block (B) is made of steel and insulated from the top head by means of a fibre plug (G) and a ring (F).

The wire of a 110-volt circuit is run in at (H) and taken off at (I).

The circuit carrying red lamps is completed by the German



Ill. No. 9.

wire (a) coming in contact with the mercury at (C) and (D) when the pressure exceeds a fixed maximum or falls below a fixed minimum.

Thumb screws (E) and (E) allow adjustability.

This device should be tested for adjustment from time to time.

L. B. Moorehouse,
Supt., Gas Dept., San Antonio Gas & Electric Co.

Ill. No. 9.

UNIQUE USE FOR TWO SMALL GAS ENGINES.

We have two small gas engines on which we have reversed the valves and belted to our exhausters for revivifiers. These we belted from the fly wheel of the gas engine to the coupling between the engine and exhauster, making a very satisfactory air pump. We also used these same appliances in removing dust from our apparatus around the electric station, pumping into a receiver, storing the air, and using as needed.

Thos. Crawford, . .
Genl. Mgr., Clinton Gas Light & Coke Co.

USE OF PNEUMATIC HAMMERS FOR CAULKING GAS MAINS.

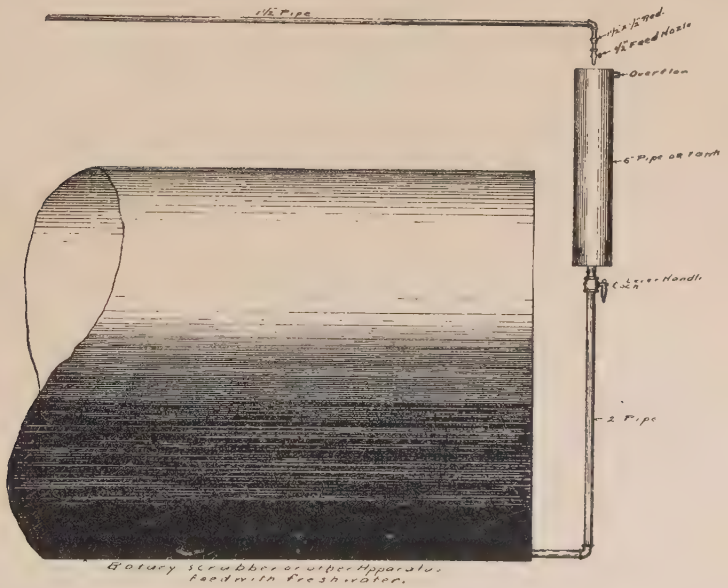
We have been using a portable plant this summer for the purpose of supplying air to the pneumatic hammers with which we have been caulking lead joints in the ditch while laying 16″ and 24″ pipe. The same plant is used also for putting 5 lbs. pressure on the line after the joints are made up, for the purpose of testing.

The plant consists of a small vertical boiler on wheels with a pressure tank in front of it, and a compressor of standard make attached to the boiler. The plant is large enough to handle two pneumatic hammers successfully at 80 lbs. pressure, and has been a great saving to us in labor, as one man can easily do with the pneumatic hammer as much as six can do by hand, and do the work better.

D. F. Burritt,
Supt., Springfield Gas Light Co., Springfield, Mass.

MEASURING FUNNEL.

In the operation of a plant it is very necessary that the foreman knows exactly how much water he is running into rotary scrubber washers, etc. In order that he may accomplish this with the least trouble a measuring funnel is placed as shown in the accompanying sketch. To operate, close the



Ill. No. 10.

cock and note the length of time until the funnel overflows. The capacity of the funnel being known, the foreman knows at once whether the supply is all right.

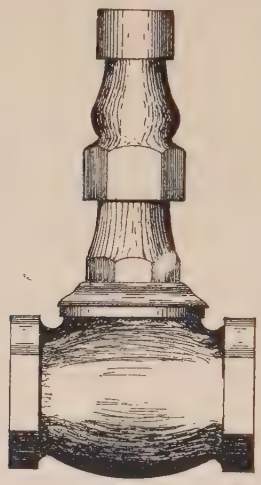
DETROIT CITY GAS COMPANY.

Ill. No. 10.

CAPPED STEAM VALVES.

Around gas works where steam lines are run long distances, it is troublesome to keep the valves which are often very little used from leaking steam and water around the stuffing boxes.

For valves that are not frequently used the following remedy has been applied. A stuffing box nut same as used on lock



Ill. No. 11—Capped Steam Valve, preventing leakage around packing.

and shield valves is threaded on the end and a cap screwed on as shown in the sketch.

DETROIT CITY GAS COMPANY.

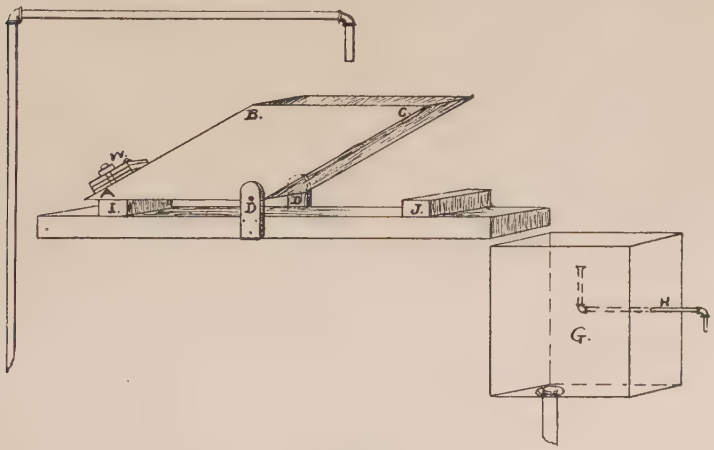
Ill. No. 11.

DUMPING BUCKET FOR PUTTING WATER INTO A SCRUBBER.

For a long time we used flushing tanks for this purpose, but when the amount of water to be put in was cut down low, the flushing tank would fail to siphon, and required constant watching. The present dumping bucket is very positive in its action. The device is described as follows:—

It consists of a box, diamond shaped on the side, and wide enough to contain the amount of water desired, turning on a trunnion "D," and caught by the rubber cushion "I" and "J." "A," "B," "C" and "D" represent the box. In our case it holds five gallons. "D" is the trunnion on which it turns. "W" is a weight made of lead washers, which is adjusted so as to

bring the box back to position as soon as it is empty of water. The trunnion "D" is placed at such a point that the box will overbalance a little before it becomes full of water. This is important, as otherwise, if the box becomes full and runs over, water will run into it without dumping it. "G" is a tank which receives the water and from which it falls into the scrubber. "H" is a small pipe which catches a thimble full of water at each dump and leads it down to a convenient



Ill. No. 12.

point of observation. As long as water is dropping from the pipe "H" the foreman knows that the device is working.

It is manifest on inspecting the diagram that when the box is empty it will remain in an upright position. When it is nearly full, it will overbalance and empty itself completely, and as soon as it is empty, it will resume the first position. The box is made long and low and wide, so that the shock of dumping and recovering will not hammer it to pieces.

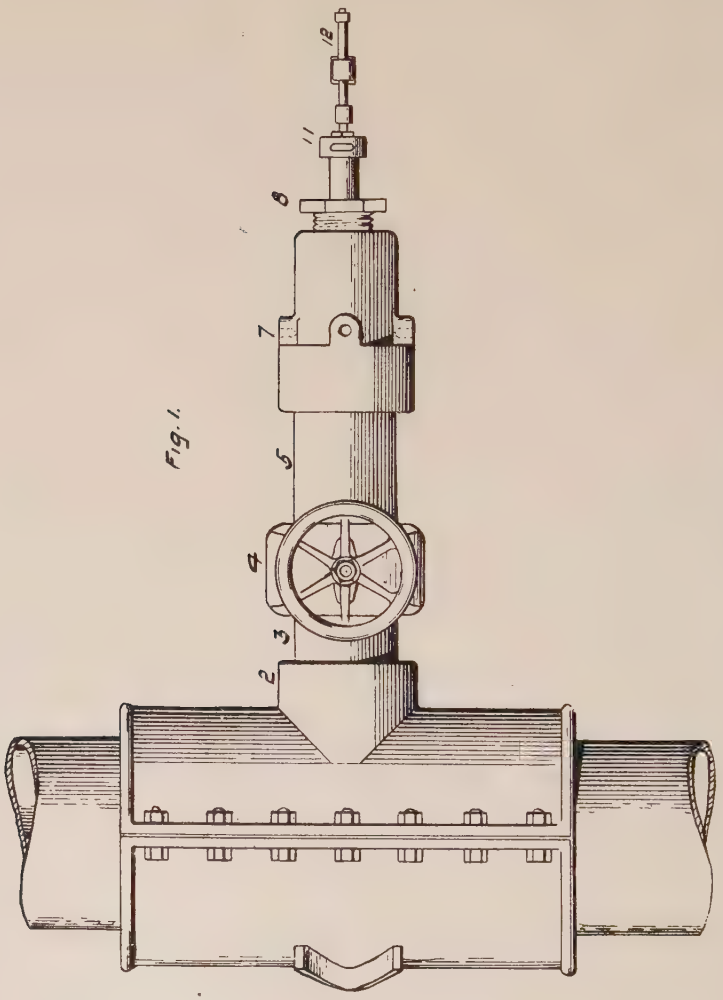
I know that dumping buckets have been used for a long time, and we have tried several different shapes. This one has proved absolutely reliable and more durable than any of the others.

DONALD MCDONALD,
Prest., Kentucky Heating Co., Louisville, Ky.

Ill. No. 12.

MACHINE FOR TAPPING GAS MAINS UNDER PRESSURE.

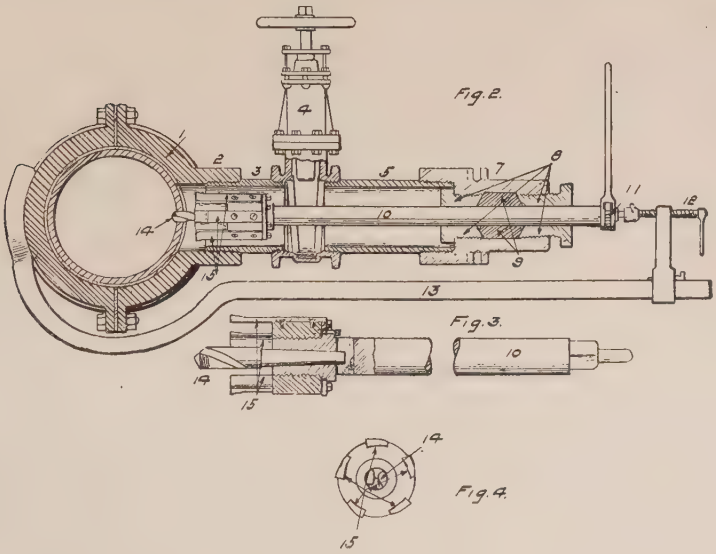
Along our high-pressure mains a great many new streets



Ill. No. 13.

have been laid out recently and to put in fitting for these streets meant cutting the line and by-passing the gas, all of

which had to be done at night with holder pressure. The tapping machines at present on the market were all too cumbersome and expensive and took up too much space, consequently I had the machine made shown in the accompanying cut, and it works most satisfactorily. With this machine we can tap 4", 6" and 8", and it can be used in a ditch 36 x 24, at any angle and without pressure. When the main is tapped the



Ill. No. 13A.

valve is in place ready for the extension and without any loss of gas or the men getting any gas.

To put on sleeve and get ready to tap requires about 2 hours, while the actual tapping requires about 30 minutes. The sleeve can be used either as a tee or cross. When the sleeve is used as a cross, we run the joints solid with lead.

The machine consists of the following parts:—

A split sleeve (1) to be put around the main to be tapped, out of the side of which is an opening (2) into which a short nipple (3) is screwed. Onto nipple (3) is screwed a standard

full-way gate (4) and into gate (4) is screwed a long nipple (5) which is of a length sufficient to enclose the tapping tools (6) when same is pulled back to clear gate. Nipple (3), gate (4), and nipple (5) are standard full-sized fittings of a size of the pipe to be connected to the main. Onto nipple (5) is screwed a head (7) in which is a stuffing box (8) which by use of packing (9) makes a gas-tight joint around the stem (10) of the tapping tool. On the end of the stem (10) is a ratchet (11) and pressure is furnished the tool by means of a screw (12) in crow's foot (13).

The operation of the machine is as follows:

Sleeve (1) is placed around the main at the point to be tapped exposing through the opening (2) the point on the main to be tapped. The sleeve is leaded and caulked, making a gas-tight fitting. Nipple (3), gate (4), nipple (5), head (7), and tool (6) are placed in position as in Figure 2, gate (4) being left open. By means of screw (12) pressure is given to tool (6) so that drill (14) engages the side of the main, and a hole is drilled. Then the knives (15) engage the main and cut a plug out of the side of the pipe. When the first opening is made in the main the nipples (3)and (5) are filled with gas but by nature of the gas-tight joint no gas escapes. When the plug is cut out of the main the tool is pulled back into the nipple (5) which brings with it the plug cut out of the main by means of the thread on the end of the drill (14). See Figure 3. When the tool is withdrawn into the nipple (5), the gate (4) is then shut and nipple (5) is unscrewed from gate (4) leaving gate ready for connecting pipe. Figures 3 and 4 show details of tapping tools.

W. J. Dorr,

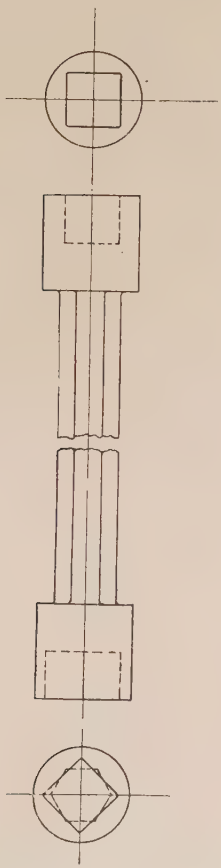
Supt., Gas Dist., Los Angeles Gas & Electric Co.

Ill. Nos. 13 and 13A.

SOCKET WRENCH.

A socket wrench for removing ½″ and ¾″ plugs from the bottom of risers. In old work it frequently occurs that a num-

ber of risers will drop so close together that it is impossible to



Ill. No. 14.—Socket Wrench.

get an ordinary wrench on the individual plugs in order to remove them.

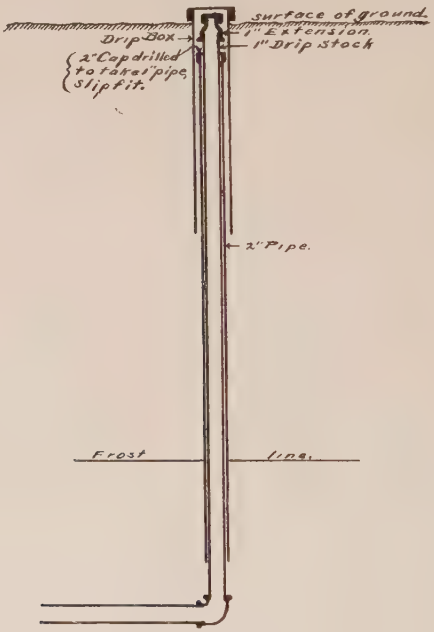
W. K. Harrington,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 14.

METHOD OF PROTECTING DRIP STOCKS.

The method shown in the accompanying sketch was adopted in order to prevent the frost breaking off drip stocks due to the upheaval of the frozen earth crust, a trouble which is experienced to some considerable extent in Detroit. The pro-



Method of installing Drip Stocks.

Ill. No. 15.

tection consists of a 2″ pipe sheath placed around the 1″ drip stock. The lower end of the 2″ pipe is below the frost line and is open, allowing any surface water which may leak in at the top to drain away. The upper end is capped with a 2″ cap having a hole in the center just large enough to allow the 1″ drip stock to slip through easily but not allow the dirt to work in between the stock and the sheath. A special male-

female coupling is placed on the end of the stock in order that the drip pumper can easily replace same if the thread becomes marred by screwing on or off the cap.

DETROIT CITY GAS COMPANY.

Ill. No. 15.

SOLID PIPE PLUG.

A special round head plug to be used in tees at the bottom of risers or at the heads of services. It is frequently difficult to remove the ordinary plug with the small square head as the edges of this head frequently become so worn that it is impossible for the wrench to get a grip. With the special round head plug this difficulty is eliminated and the plug is always readily removed.

W. K. HARRINGTON,

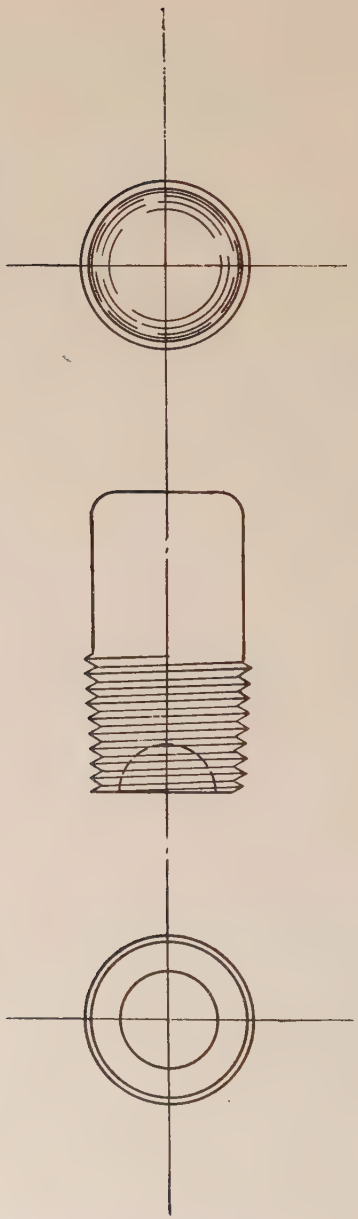
Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 16.

COATING SERVICE PIPES.

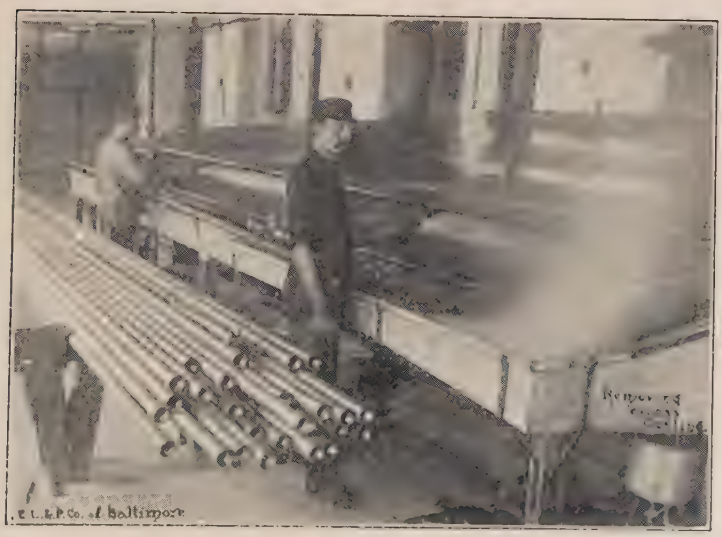
The operation of coating the pipe also carried with it—clearing out the pipe of any scale or other material and also testing the pipe for leaks. The complete process is as follows:—

The pipe is first scraped with wire brushes, then rubbed off with a piece of burlap; then it is lifted to the coating trough and one end pushed over a nipple, having around it a soft washer to make it steam tight. Steam is then blown through it into the drainage department alongside of the through; then a lever with soft washer attached to it is pushed over the open end of the pipe, the lever being held in place by a projection on its lower end, which fits into one of the holes in the wrought iron plate shown in the picture. There are a sufficient number of holes in this plate to accommodate the varying lengths of pipe. Steam under 80 lbs. pressure is again turned into the pipe long enough to see that it is tight, after which the pressure is relieved at a stop-cock on the end



Ill. No. 16.—Solid Pipe Plug.

Ill. No. 17.



Ill. No. 17A.

Ill. No. 17B.

Ill. No. 17C.

of the pipe next to the steam valve. The pipe is then lifted by two wooden handles, which are cupped out sufficiently to cover the threads on the ends of the pipe, and after dipping, the pipe is placed on a drain board above the trough, and all superfluous tar is taken off by running a scraper gently over the pipe from end to the other.

The whole operation of cleaning out, testing and dipping a length of pipe, does not occupy more than about two minutes.

For the coating mixture, we are using what is known as

Ill. No. 17D.

the "Cincinnati Mixture," and our practice is to wrap all service pipes with muslin after they are laid, the wrapped pipe is then painted with a mixture of coal tar with a sufficient quantity of water gas tar to keep it thin in cool weather.

GEO. BEADENKOPF,

Engineer, Consolidated Gas, Electric Light & Power Co. of Baltimore.

Ill. No. 17, 17A, 17B, 17C and 17D.

THE LYNN MAIN CART.

In our experience with main laying, we found one difficulty

Ill. No. 18.

to be the moving of the tool box. It required six men to

move the same and the loss of some little time, as the tools had to be taken from the box first, the box carried ahead, then the tools carried ahead and replaced in the box, so we decided to build a box on wheels, of which the following is a description.

It consists of a four-wheel cart, 1½" axle, with frame 9' long by 3' 6" wide by 3' 2" high, with pitched top.

In the rear is a vertical partition 2' back from the end, which gives a place for lanterns, fittings, die stocks and other small tools, with a vise attached to the side of same for pipe threading.

Another partition 2' 4" from the bottom runs horizontally, in which are stored picks, shovels, bars, and all tools of that nature, it having a side door which turns down.

In the top part one side of the pitched top is hinged to the middle and turns up, which gives storage for small tools. The front wheels are 32" in diameter and set 2' out from the cart on an iron tongue which allows them to turn in a short radius, there being a handle attached which may be attached to a team for hauling. The rear wheels are 36" in diameter.

We find this cart will take care of tools for about twenty-five men.

CHAS. F. PRICHARD,
Vice Pres. & Genl. Mgr., Lynn Gas & Electric Co.,
Lynn, Mass.

Ill. No. 18.

THE LYNN SERVICE CART.

Having found that a great deal of time was wasted by the men in going to the shop for fittings and tools which were needed, we had built a tool cart with the following description, which we have been using now for about fifteen years.

The cart is a two-wheel, drop axle, push type. The axle is 1½", with a drop of 8½", which brings the body near the ground. The wheels are 44" in diameter with 2-inch fellies. The body is 5' 6" long by 2' 9" wide by 1' 11" high. The

frame is of ash, well mortised, with a center rail extending 3'

Ill. No. 19.

4" beyond the body, with an end bar which makes the handle The cross bar of handle has an iron staple which is attached to the teams for hauling when the distance is too great for the

men. The cover of the cart is hinged at 4′ 6″ from the back end and turns up and over on the front bar of the cart, the handle being supported by an iron stud which is attached to the cover and raises on front bar.

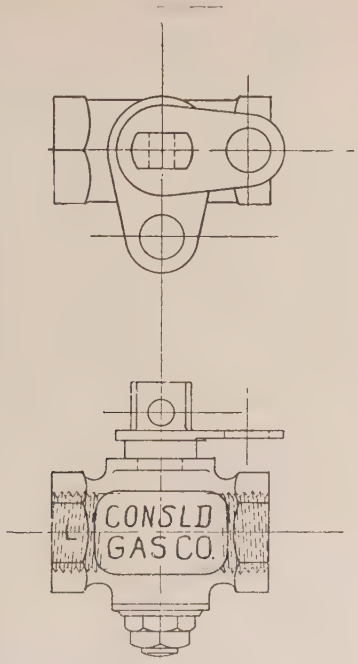
The cart is supplied with picks, shovels, bars, die stocks, fittings, and all tools used for general service and repair work.

The vise is attached to the middle back cross bar of cart, which is 4″ x 5″. The vise is set on an angle so that when the cart is tipped down in front and the foot irons placed in rear, the vise and the cover are in line so that the pipe may be placed in the vise and threaded.

In the top of the cart is a box or drawer which slides from one end to the other, in which are kept all small tools and fittings.

CHAS. F. PRICHARD,
Lynn, Mass.

Ill. No. 19.



Ill. No. 20.—Right and Left Hand Cock.

RIGHT AND LEFT-HAND COCK FOR RANGE.

A special range cock which is made with right and left threads. The use of these cocks obviates the necessity of using a union, long thread, or right and left coupling.

W. K. Harrington,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 20.

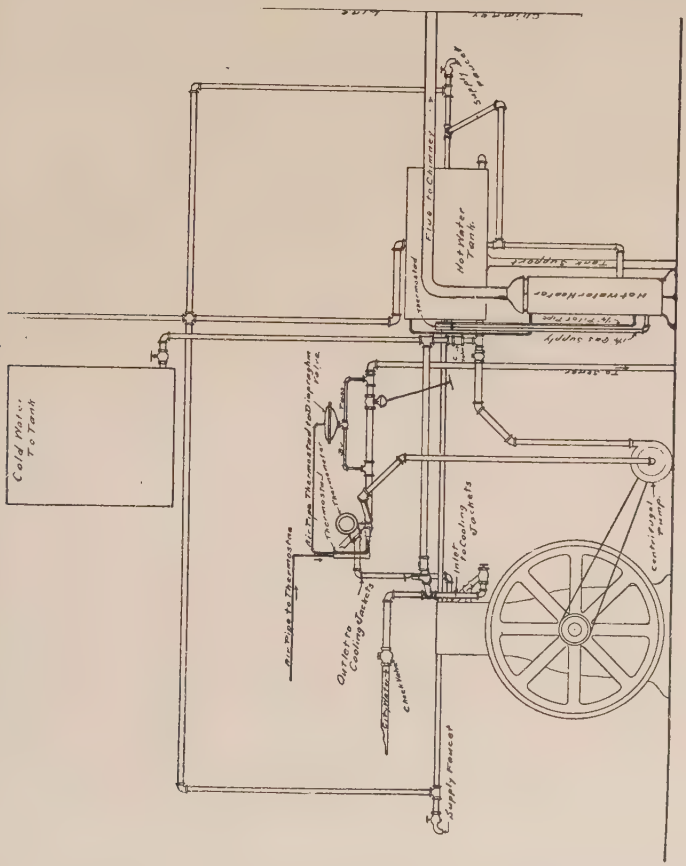
METHOD OF USING THE COOLING WATER OF A GAS ENGINE IN THE HOT WATER SYSTEM OF AN OFFICE BUILDING.

The accompanying sketch shows a 125 H. P. gas engine combined with a hot water storage system in such a way that all or a part of the cooling water from the engine is utilized in the hot water tank supplying an eight-story office building. The system is made up as follows:—

The city water pressure not being great enough, the water supply is first pumped into a storage tank in the attic. This head supplies all the water used in the building. The cooling water taken from this tank passes through the engine into a branched pipe, one arm of which leads through a thermostatic controlled valve to the sewer and the other leads through a centrifugal pump to the hot water storage tank. This is connected with an instantaneous gas water heater and with the circulating system of piping as ordinarily used in office buildings.

According to the well-known principle the centrifugal pump, running at a constant speed, supplies a constant head of water at its outlet, within the limits of its capacity. The pressure, therefore, on the hot water tank does not vary appreciably, although the volume of water passing through it

varies from zero to the maximum amount used in the building. In order that a constant temperature may be held on the engine, a standard make of thermostat is placed in the outlet line and operates the diaphragm valve in such a man-



Ill. No. 21.

ner that more or less water passes to the sewer, according to the temperature. With this combination, the hot water system is supplied with the variable amounts of hot water required at a temperature of about 140° F., while the thermostat at the same time is enabled to hold a constant tempera-

ture on the engine. The gas heater, as shown, automatically raises the temperature of the water to 150° F., the amount required.

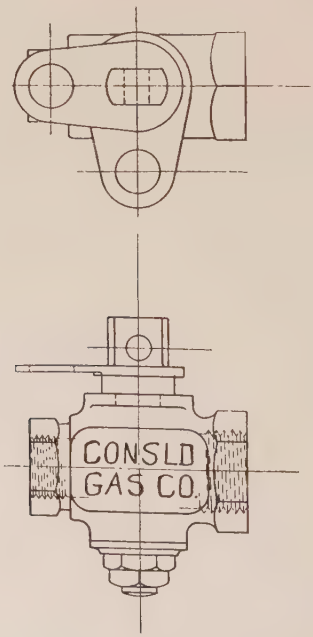
The system is so connected up with check valves that if the water supply in the cold water storage tank gave out, the city water would furnish water for the engine.

DETROIT CITY GAS COMPANY.

Ill. No. 21.

SPECIAL REDUCING METER COCK.

A 3-light meter screw is for ⅜″ pipe where as the meter



Ill. No. 22.—Reducing Cock.

is connected up with ½″ pipe and in the same way a 5-light meter screw is for ½″ pipe and is connected up with ¾″

pipe, but in making the reducing cock from ½″ to ⅜″ and from ¾″ to ½″, it does away with the reducing fittings.

W. K. Harrington,
Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 22.

METHOD OF REPAIRING OLD METER CASES.

Very satisfactory results have been obtained by shellacing a piece of diaphragm leather and sticking it to the sides, bottom, and top of the inside of old meters where the tin has worn off, leaving a rusty iron surface exposed which rough surface tends to cut the leather of the diaphragm.

James Daly,
Foreman Meter Shop, New Orleans Gas Light Co.

MELTING RIMS OFF METER DISCS.

For melting rims off discs,—a cast iron skillet placed over a hot plate and an iron ring somewhat smaller than the diameter of the disc is placed in the bottom of the skillet and enough solder melted in the skillet to nearly reach the top of the ring. A disc placed over this ring will have its band removed almost instantly. A small boy can operate it so that a thousand or more discs per day can be cleared of the old bands easily.

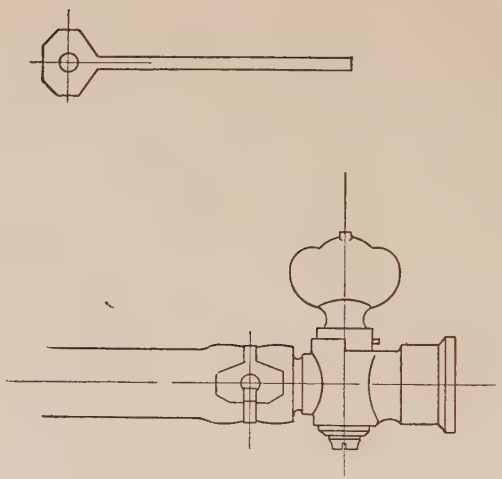
James Daly,
Foreman Meter Shop, New Orleans Gas Light Co.

HOSE CLAMP.

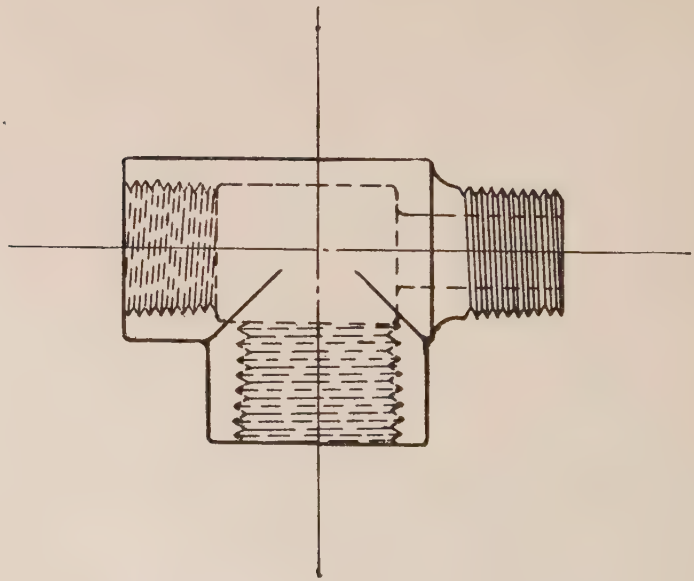
A simple form of strap to be used on tubing in fixing the same to a hose cock or an appliance.

W. K. Harrington,
Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill.No. 23.



Ill. No. 23.—Hose Clamp.



Ill. No. 24.—Male and Female Reducing Tee.

MALE AND FEMALE REDUCING TEE.

A special ⅜″ x ½″ right and left reducing tee to be used on ceiling drops in connecting up small gas appliances. The accompanying sketch explains same.

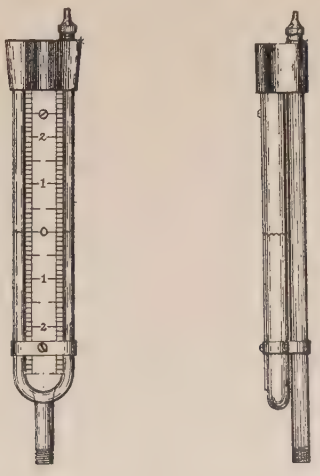
W. K. Harrington,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 24.

SAFETY "U" GAUGE.

While considering the advisability of placing "U" water



Ill. No. 25.—Safety Pressure Gauge.

gauges in the homes of a large number of our employees in order that they could watch the pressure conditions and report on same, the need of a safety gauge in which the water could not evaporate or blow out become apparent. The attached sketch shows a home-made gauge with an ordinary bicycle valve soldered in the vent on the low pressure side. To read the gauge, the cap is unscrewed and the valve held open with the finger until the reading can be made. The entire gauge as shown can be made up for about 70 cents apiece.

Detroit City Gas Co.

Ill. No. 25.

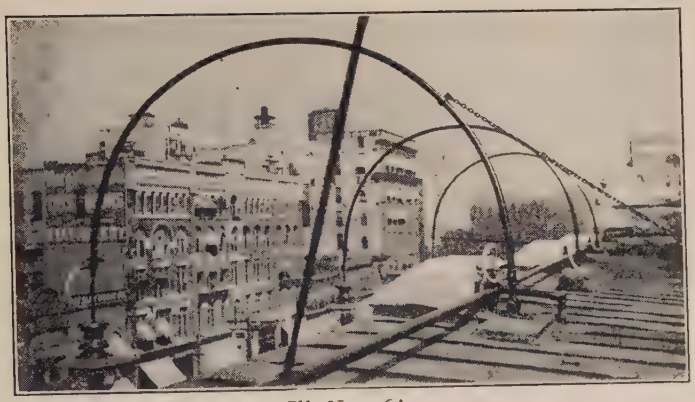
AN ARRANGEMENT OF ROOF LIGHTS.

Mr. J. C. Ross, of the Utah Gas & Coke Co., contributes the accompanying photographs showing a method of suspending

Ill. No. 26.

lights over the edge of flat roof buildings. The position of the lights can be changed and are readily accessible for maintenance when they are drawn back over the roof. Means are provided for lighting the arcs in position.

Ill. No. 26, 26A, 26B 26C and 26D.



Ill. No. 26A.

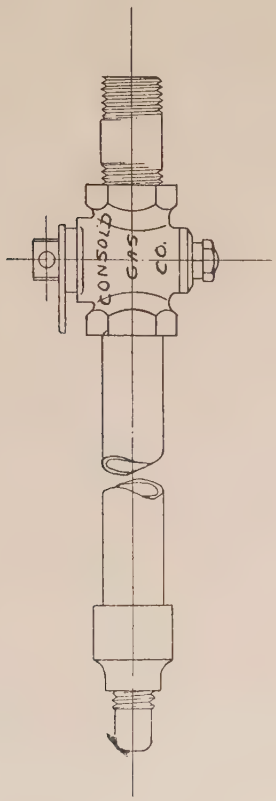
Ill. No. 26B.

Ill. No. 26C.

Ill. No. 26D.

SAFETY DRIP.

A drip which may be emptied in safety in dark places. A cock is placed in the drip so that when it becomes necessary



Ill. No. 27.—Safety Drip.

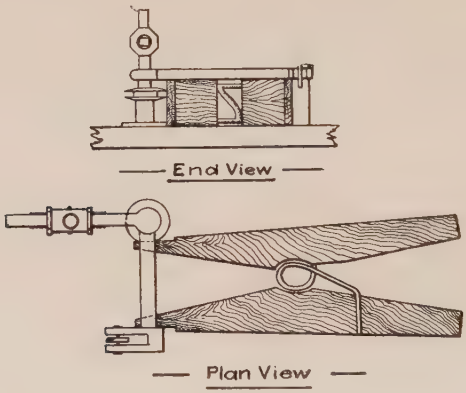
to empty the drip, the cock is shut and the plug removed from the bottom. This avoids the danger of a sudden flow of gas in case the plug at the bottom should fall out or be dropped

and enables the fitter to readily stop the flow of condensation or gas in case of trouble.

W. K. Harrington,
Genl. Supt. Meters, Consolidated Gas Co. of New York.
Ill. No. 27.

CLAMP FOR ADJUSTING METER VALVE.

An ordinary paper clamp or spring clothes pin can be quick-



Ordinary paper clamp quickly used in wedgin crank shaft when adjusting dry meter valves.

Ill. No. 28.

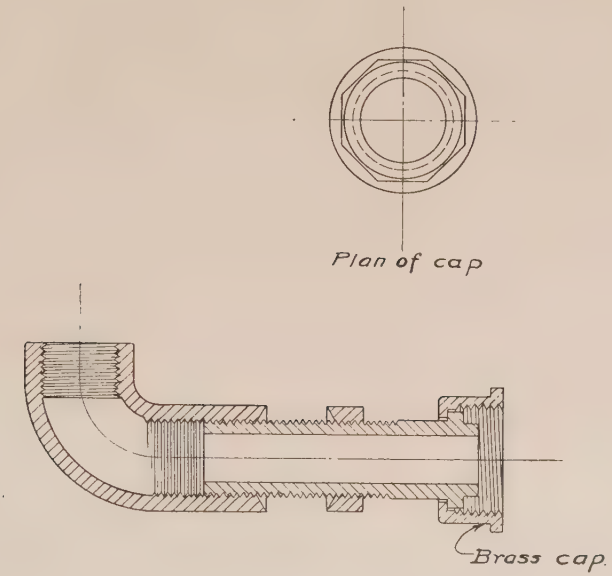
ly inserted, wedging the crank shaft so that the tangent arm can be changed with ease, as shown in the cut.

James Daly,
Foreman, Meter Shop, New Orleans Gas Light Co.
Ill. No. 28.

AN ADJUSTABLE METER CONNECTION.

The accompanying sketch shows an adjustable meter connection, to be used in connection with setting meters in iron. It sometimes happens in setting a meter in iron that the inlet

and outlet connection will not make up even, consequently there is a tendency to bring a strain on the cones of the meter.



Ill. No. 29.—Adjustable Iron Meter Connection

By using a device of this nature such a strain is unnecessary.

W. K. Harrington,

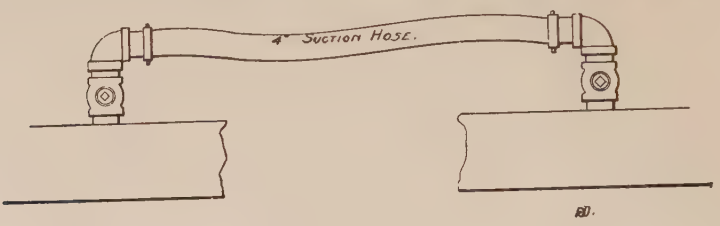
Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 29.

TEMPORARY GAS SUPPLY TO BE USED WHEN CUTTING MAINS.

We have many times found it necessary to maintain some form of gas connection, while a special was inserted in a

main or a new or larger pipe substituted, and the scheme shown



Ill. No. 30.

in the sketch has proven to be very convenient and quickly applied.

A. F. Traver,
Supt., Gas Dept., Denver Gas & Electric Co.
Ill. No. 30.

SOLDERING IRON.

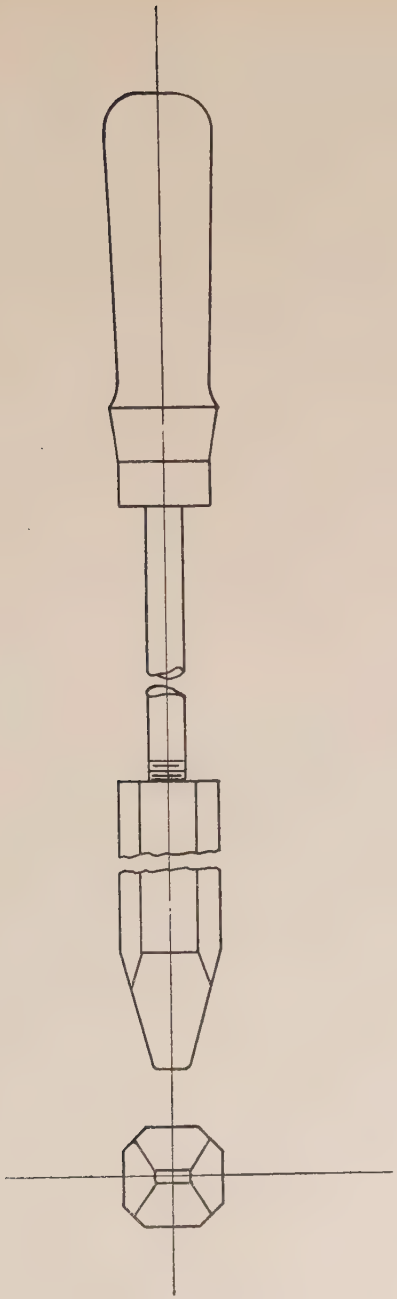
The accompanying cut shows a soldering iron, the copper being of the desired size and tapped; the handle being screwed in. This permits of a greater portion of the copper being used before the soldering iron is discarded. Also permits of a greater price being obtained for scrap copper and makes a net reduction in the cost per soldering iron of ten cents or more.

W. K. Harrington,
Genl. Supt. Meters, Consolidated Gas Co. of New York.
Ill. No. 31.

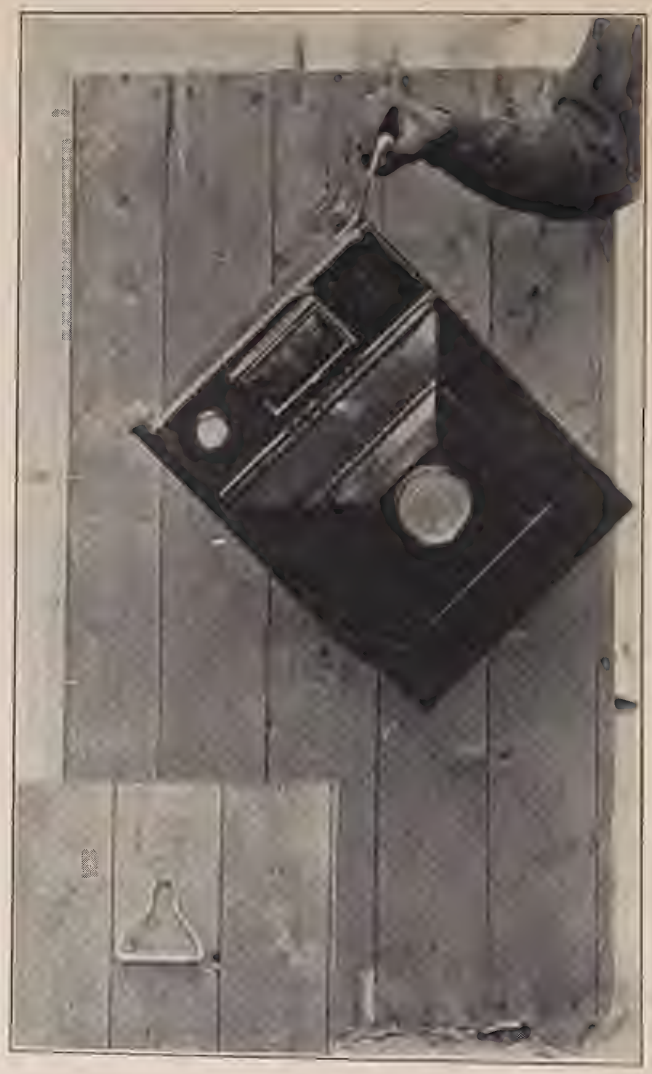
METER CARRYING DEVICE.

The accompanying photograph shows a meter carrying device made with a ⅜" nipple, 4" long for the handle and a 6 inch wire pipe hook bent the proper shape soldered into the ends of the handle from the eyelet.

A. Hurlburt,
McGowan, Small & Morgan Co., Kansas City, Mo.
Ill. No. 32.



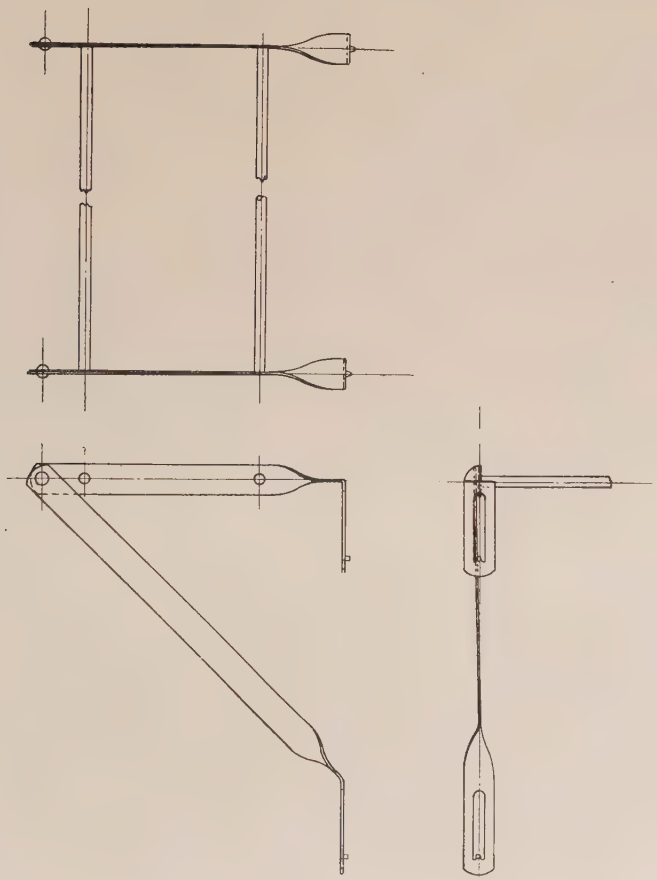
Ill. No. 31.—Soldering Iron.



Ill. No. 32

METER BRACKET.

The accompanying cut shows a meter bracket so constructed



Ill. No. 33.—Meter Bracket.

as to readily permit the setting of a meter over a door jamb.

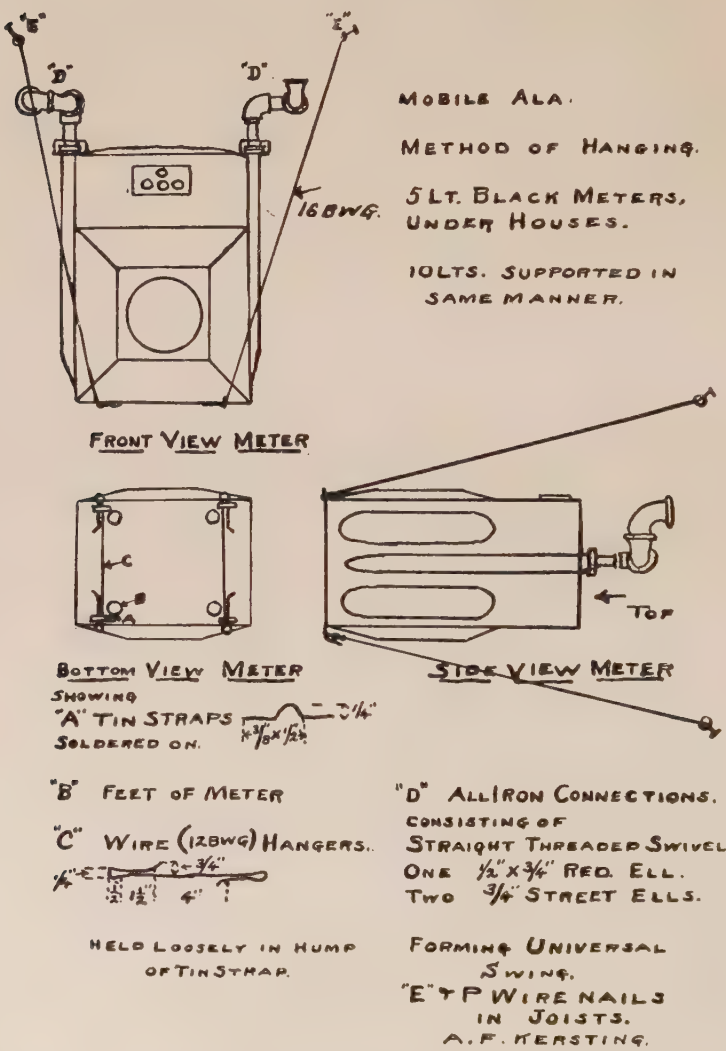
W. K. HARRINGTON,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 33.

METHOD OF SETTING METERS UNDER HOUSES.

The sketch shows our method of setting meters under #2.


"E"
"D"
"D"
"E"
16 BWG.
MOBILE ALA.
METHOD OF HANGING.
5 LT. BLACK METERS, UNDER HOUSES.
10 LTS. SUPPORTED IN SAME MANNER.
FRONT VIEW METER
C
TOP
BOTTOM VIEW METER SHOWING "A" TIN STRAPS SOLDERED ON.
SIDE VIEW METER
"B" FEET OF METER
"C" WIRE (12BWG) HANGERS.
HELD LOOSELY IN HUMP OF TIN STRAP.
"D" ALLIRON CONNECTIONS. CONSISTING OF STRAIGHT THREADED SWIVEL ONE ½" X ¾" RED. ELL. TWO ¾" STREET ELLS.
FORMING UNIVERSAL SWING.
"E" T P WIRE NAILS IN JOISTS.
A. F. KERSTING.

Ill. No. 34.

houses. As there are practically no cellars here and the

majority of the meters are set under the house, we adopted the plan of hanging the meters as per sketch, and find it very satisfactory. Two wire hangers are held loosely by two tin straps each, which are soldered to the bottom of the meters. All iron connections are used on both inlet and outlet of the meter, and wires are attached to the loops of the wire hangers and to nails driven into the joists at four points in such position that each set of wires is opposed to the other, forming a very secure support.

By this method we overcome all the usual disadvantages of meters set under close places, below floors of houses where bricks and other blocking are so frequently used, which, of course, have a tendency to rust the bottom of the meter.

All our prepay meters are set in the house, generally in the kitchen. Our plan is to use a block 1 x 3 x 6, which is toe-nailed on the edge to the floor directly in the center of the meter from front to back. This permits air circulation and thorough access for cleaning the floor, thereby preventing the rusting of same.

A. F. Kersting,
Supt., Mobile Gas Co., Mobile, Ala.

Ill. No. 34.

WRENCH FOR REMOVING COCKS FROM RANGES.

The accompanying cut shows a special wrench for removing cocks from ranges. In case the ordinary wrench is used, the cocks are frequently damaged.

W. K. Harrington,
Genl. Supt. Meters, Consolidated Gas Co. of New York.

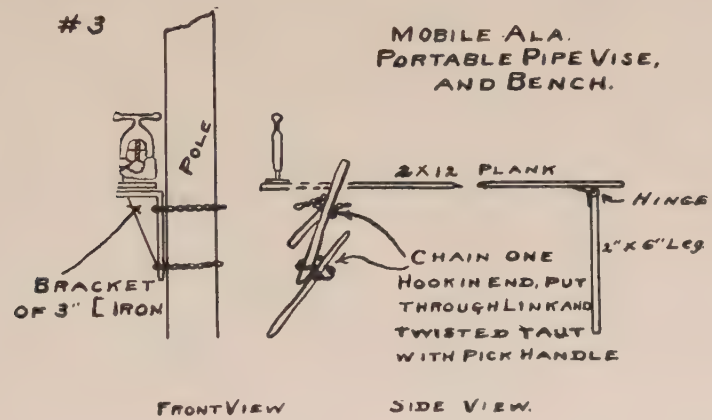
Ill. No. 35.

PORTABLE PIPE VISE AND BENCH.

The bracket is made of small channel iron, properly braced, which is fastened securely to a pole or tree by a chain which is tightened by simply twisting with a pick handle. This

Ill. No. 35.--Stove Cock Wrench.

has proven of advantage where we are doing considerable ser-



Ill. No. 36.

vice work, as it can be transported readily from one place to another without the use of a wagon.

A. F. KERSTING,
Supt., Mobile Gas Co., Mobile, Ala.

Ill. No. 36.

EXPANSION PLUG.

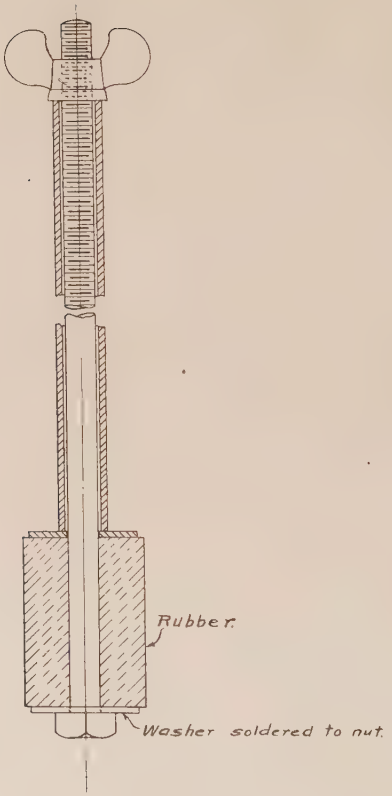
This expansion plug is to be used in connection with work on live gas. The plug is inserted in the opening and the thumb screw turned, thereby expanding the rubber and shutting off the flow of gas.

W. K. HARRINGTON,
Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 37.

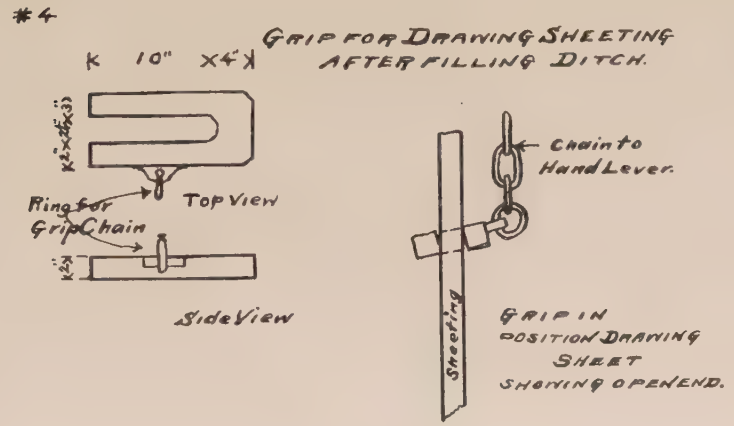
GRIP FOR DRAWING SHEETING AFTER FILLING DITCH.

As shown by the sketch, it consists of forging in the shape of a "U," the legs being slightly further apart than the thickness of the plank on which it is being used. A chain attached



Ill. No. 37.—Expansion Plug.

to the hand lever connects with a ring on one side of the grip and forms a very positive hold when strain is applied. This is a vast improvement over the old method of using a chain



Ill. No. 38.

twisted around each piece of sheeting, for it will be seen that same may be applied to the sheeting from the open edge without any necessity of prying the sheeting apart.

A. F. Kersting,

Supt., Mobile Gas Co., Mobile, Ala.

Ill. No. 38.

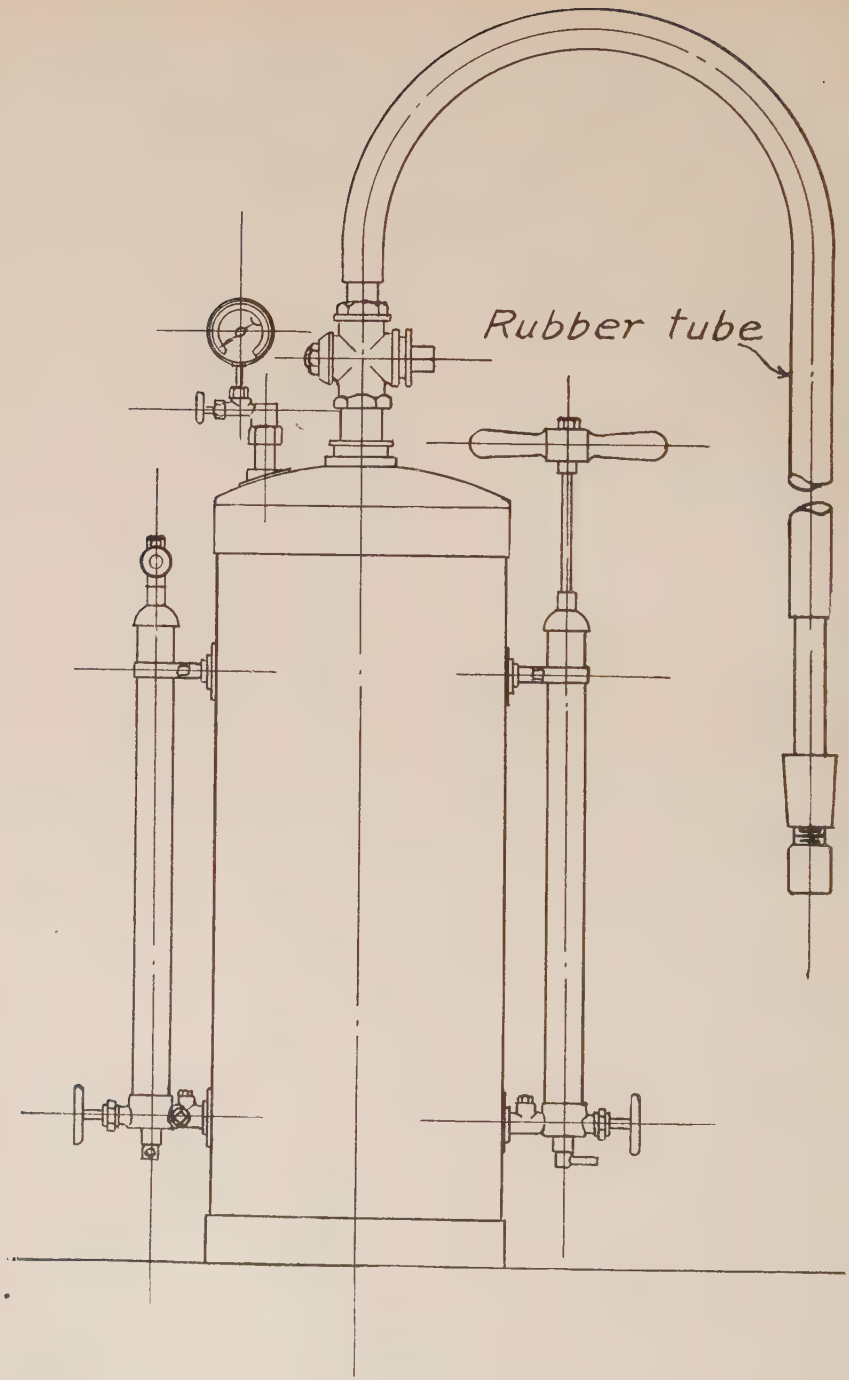
SPECIAL PUMP.

An apparatus used in clearing services where the ordinary service pump is not effective. It consists of an ordinary cylindrical tank with an air pump on either side and a small gauge to show the amount of pressure.

W. K. Harrington,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

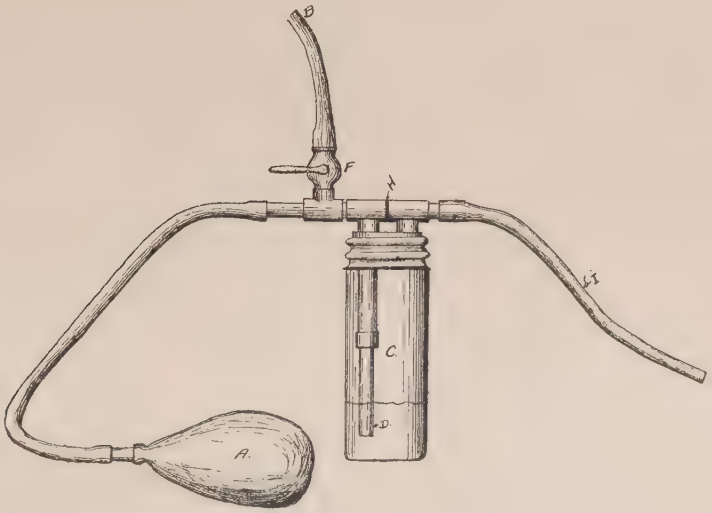
Ill. No. 39.



Ill. No. 39.--Special Pump.

PORTABLE INSTANTANEOUS LEAK DETECTOR.

The accompanying sketch shows a device which will immediately indicate the smallest leak in a closed system to which the apparatus may be attached. A mouthpiece or pressure tube "B" is connected through a cock "F" with both an elastic rubber bag "A" and with a glass tube "D" which



Portable Leak Detector.

Ill. No. 40.

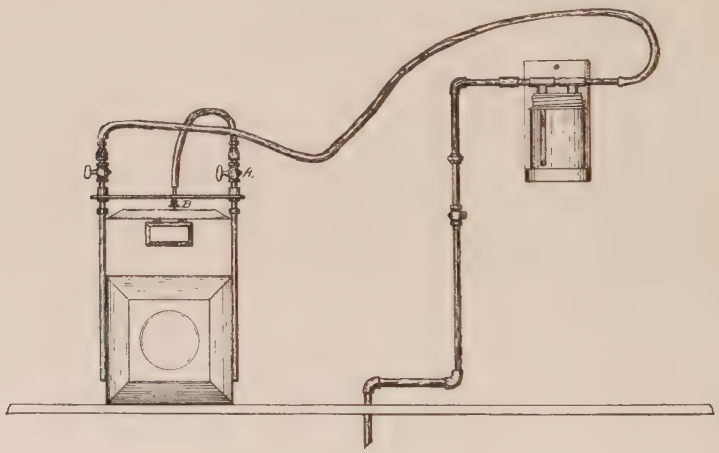
projects below the water in the air-tight bottle "C." The joint at "H" is blank and the tubing connects the system to be tested with the air chamber above the water in bottle "C." In operation, pressure is applied at "B" with cock "F" open. It immediately equalizes throughout the system. The cock "F" is then closed and if there is any leak, the pressure beyond "I" will be reduced and the pressure from the elastic bag will cause bubbles to pass through the water in the jar "C" at a rate proportional to the size of the leak. This apparatus is very handy in the Shop for testing for leaks in

fixtures, tanks, etc., while out on a job it is especially adapted to test house-piping. DETROIT CITY GAS COMPANY.

Ill. No. 40.

TESTING METERS FOR LEAKS.

The attached sketch shows the application of wrinkle No. 51 to testing meters. The pressure line is connected with the inlet of the meter through a test bottle similar to the one described. The outlet of the meter is connected by flexible tubing and a small nozzle in such a way that the pressure coming through the meter equalizes with the dial chamber above.



Ill. No. 41.

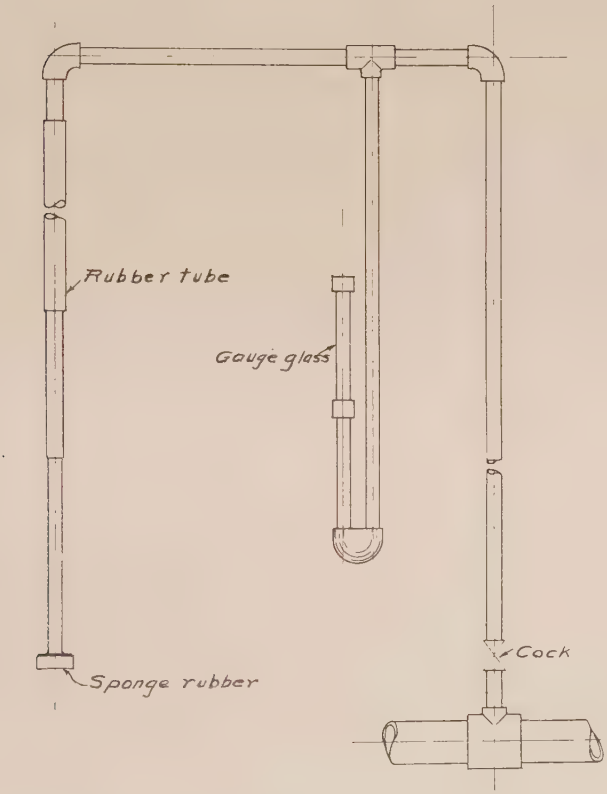
In operation, if the gas bubbles through the bottle when the outlet cock "A" is shut, it indicates a leak in the stuffing boxes or lower case of the meter. If there is no leak, the cock "A" is opened and the nozzle "B," which is surrounded by a rubber cork, is inserted in a hole punched in the top of the meter. If the jar now indicated a leak, it must be in the dial chamber. The pressure on the test line should be very constant in order to get the best results.

DETROIT CITY GAS COMPANY.

Ill. No. 41.

GAUGE FOR DETECTING LEAKS IN METERS.

The accompanying cut shows a gauge for determining leaks in meters. The height and the smallness of the diameter of the water column is such that a small leak is readily shown.



Ill. No. 42.—Gauge for Testing Diaphragms and Channels:

The portion of the back of the glass is covered with sealing wax so that any variation in the height of the water column is very easily discerned.

W. K. Harrington,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 42.

CARD SHOWING EMPLOYEES' RECORD.

These cards are kept on file and show a complete history of employee from the time of first employment until discharged, or until the employee resigns.

W. K. Harrington,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. Nos. 43 and 43A.

BOX FOR INDEX GLASS ON LARGE METERS.

An index box which permits the renewal of the index glass on large meters on the district thereby obviating the necessity of bringing in a meter to the shop on account of a broken dial glass. Owing to the locality in which large meters are usually set, the dial glass is more liable to be broken than in the smaller meters.

W. K. Harrington,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 44.

FITTING CHAIN AND LOCK.

In many cases it is necessary to leave fittings for a job some time before the workmen are there to take care of them. The accompanying sketch shows a way of locking them up around some column or fixture. They are as safe with this precaution as though they were in a fitting box.

Detroit City Gas Company.

Ill. No. 45.

GAUGE FOR TESTING DIAPHRAGMS AND CHANNELS OF METERS.

The accompanying cut shows a gauge to be used by Meter Repairers for testing the diaphragms and channels of meters at the bench. This enables the repairer to discover many leaks at the bench which would ordinarily be overlooked until

Name ____ No. ____

Address ____ {St. / Ave.} No. ____ {Borough / City} ____

Age {Married / Single} Date of employ ____ Rating at time employed ____ Qualified for ____

Rated now ____ Mutual Aid {Yes / No} Friendly Aid {Yes / No} Steady List {Yes / No} References {Ye / No}

Pay last increased ____ From ____ To ____ Employed by other Co. {Yes / No} Name of other Co. ____ Cause for leaving ____

Rating in other {Co. / Br.} ____ Employed by other Br. {Yes / No} Name of other Br ____ Cause for leaving ____

Disch. from other {Co. / Br.} {Yes / No} Cause for discharge ____ Discharged by ____

GENERAL CHARACTERISTICS

Neat	Slouchy
Quick	Slow
Ambitious	Indifferent
Strong	Delicate
Accurate	Careless
Sober	Drinks
Industrious	Lazy
Quiet	Agitator
Tall	Short
Dark	Light
Stout	Thin

GENERAL CAPACITY

Superintendent	Connect Ranges	Rep. Stoves {Shop / Dist.}	Watchman
Asst. Supt.	Connect W. B.	Gen. Complaint	Janitor
Foreman	Burners	Meter Opener	Messenger
Asst. Foreman	High Bill	" Repairer	Helper {Shop / Dist.}
Clerk {Pay Roll / Meter / Stove / Shipping / Ticket / Store Room}	P. P. Complaints	" Proven {O. T. / C. T.}	Carpenter
	Has P. P. Keys	" Gasser {O. T. / C. T.}	Pipe Mach. Man.
	No Gases	" Washer	
Inspector	Exchange Meters	" Painter	
Fitter	Exchange Stoves	P. P. Aprentice	
Measurer	Index	Stove Cleaner	
Helper	Test Meters	Sheet Iron Worker	
Set Meters {Large / Small}	Lock or Unlock	Dias. {Sewer / Tier}	

Ill. No. 43.

TIME LOST

Including Dates	Reason	Paid for	Full or Half Time	Amount Paid

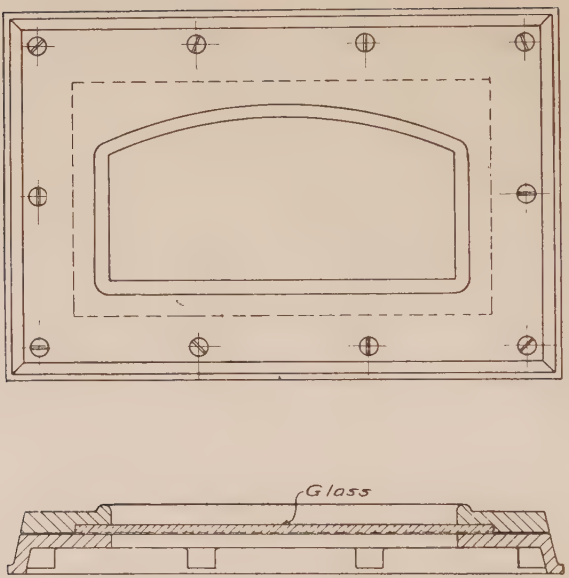
DISCHARGED

Date	Reason.	Company	By whom

INCREASE OF WAGES

Date	From	To	Reason

Reported by	Date of Report	Reported for



Ill. No. 44.—Box for Index Glass on Large Meters.

discovered by the Gasers. The use of this gauge obviates the necessity of sending the meters back to the repairer to be again opened and repaired on account of leaks.

W. K. Harrington,

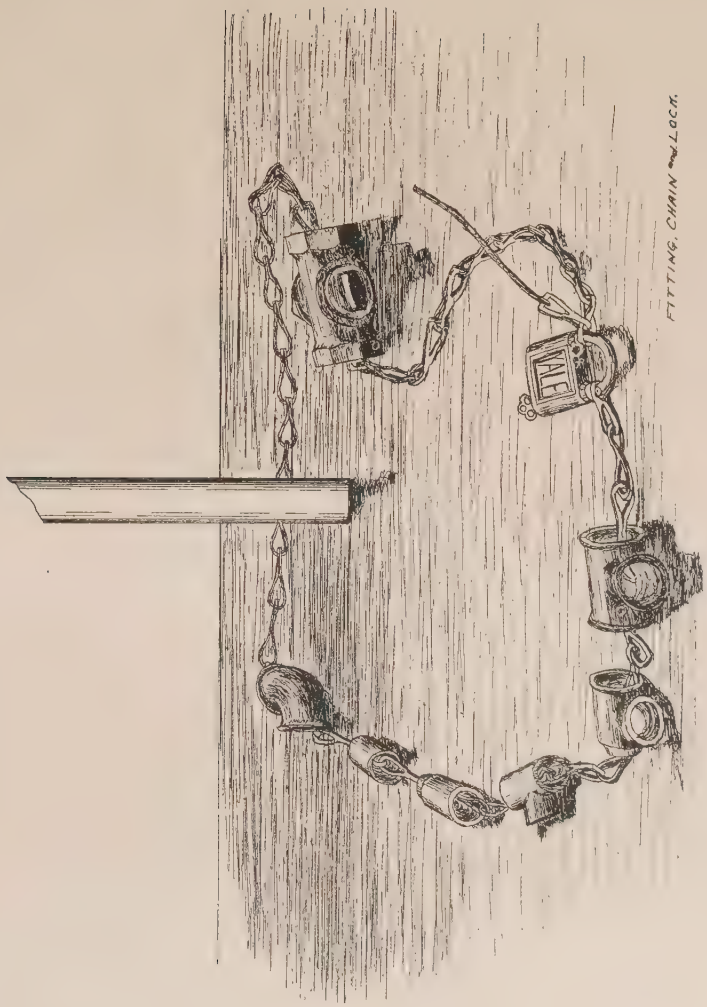
Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No.46.

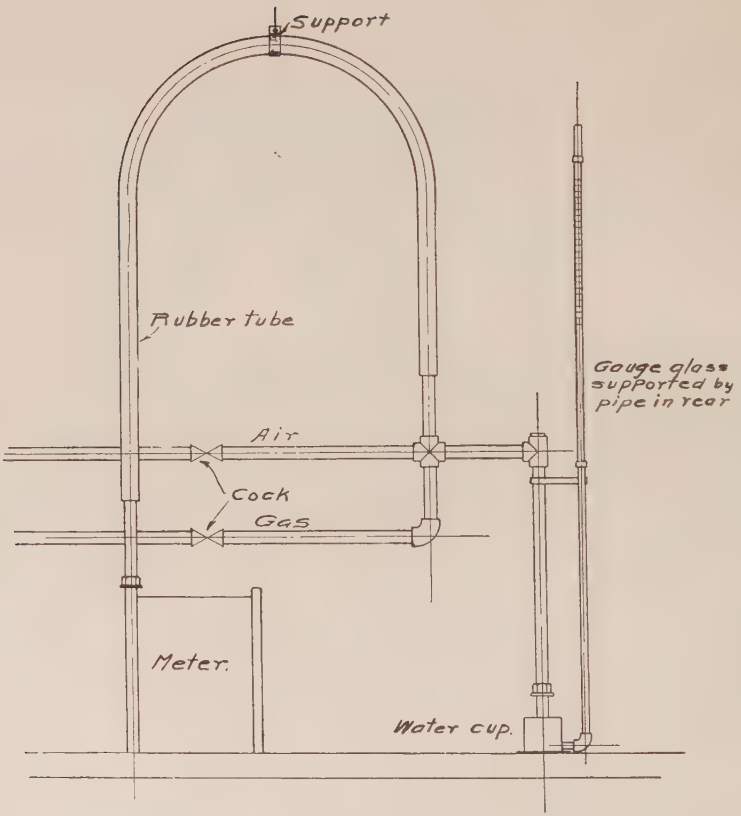
THE USE OF SMOKED GLASSES FOR ADJUSTING INVERTED LIGHTS.

The maintenance men in Detroit carry smoked glasses for use in making careful adjustment of reflex and other inverted burners. In this way they are enabled to examine the light very closely without injury to the eye.

Detroit City Gas Company.



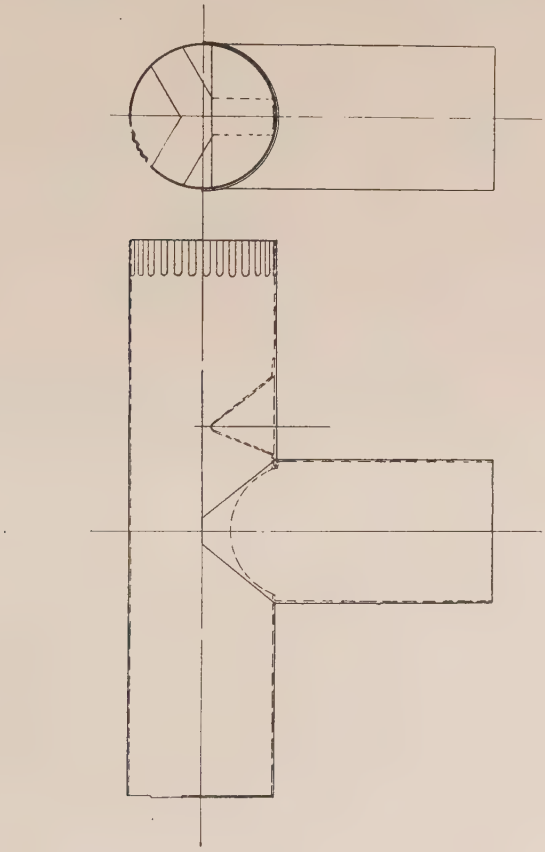
Ill. No. 45.



Ill. No. 46.—Gauge for Detecting Leaks at Meter.

BAFFLE PLATE FOR GAS FLUE.

A special form of flue tee to be used in setting gas ranges. The arrangement is such that no explosion will occur due to



Ill. No. 47.—Baffle Plate for Stove Flue.

back draft. In case there is such a downward or back draft the current of air will strike the deflector and pass out at the bottom of the tee.

W. K. Harrington,

Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 47.

METHOD OF REPAIRING BROKEN FIXTURES.

Having experienced more or less trouble from broken arms on fixtures, caused by the use of portable gas tubing, we devised a scheme of our own to overcome same.

We took the header out of a four light fixture, drilled a one-eighth hole in the bottom of it, put in a short nipple in the end of which we attached a portable lamp cock, which came just below the brass casing making a tip or point at the bottom of the fixture, doing away with the possibility of breaking the arms by the weight of the gas tubing.

NEW LONDON GAS & ELECTRIC CO.,
New London, Conn.

METER GEARING.

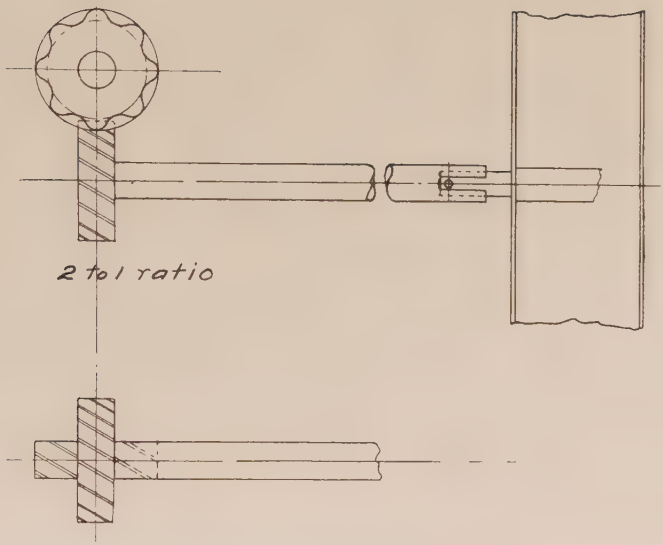
A gearing between the index shaft and the crank shaft of the meter whereby the lost motion between these two parts is materially reduced. The lost motion between these parts is frequently the source of great annoyance in the proving and testing of the meter.

W. K. HARRINGTON,
Genl. Supt. Meters, Consolidated Gas Co. of New York.
Ill. No. 48.

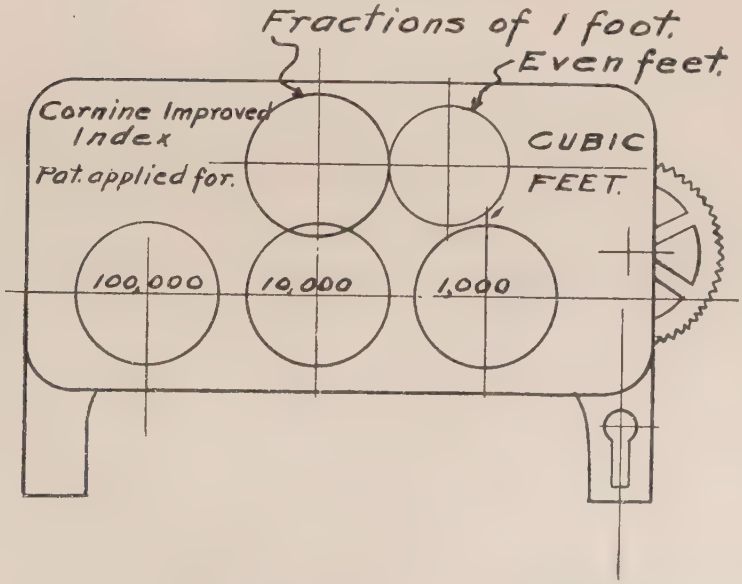
ADJUSTABLE INDEX.

An index so arranged that the hands may be readily set back to zero without operating the whole of the mechanism. This is done by inserting a key which throws out a part of the gearing thereby permitting the main dial wheels to be readily set back to zero. The wheels cannot be moved until the key has been inserted and turned; neither can the index now be put on until the key has been removed. The removing of the key brings that part of the mechanism which has been thrown out of gearing into place.

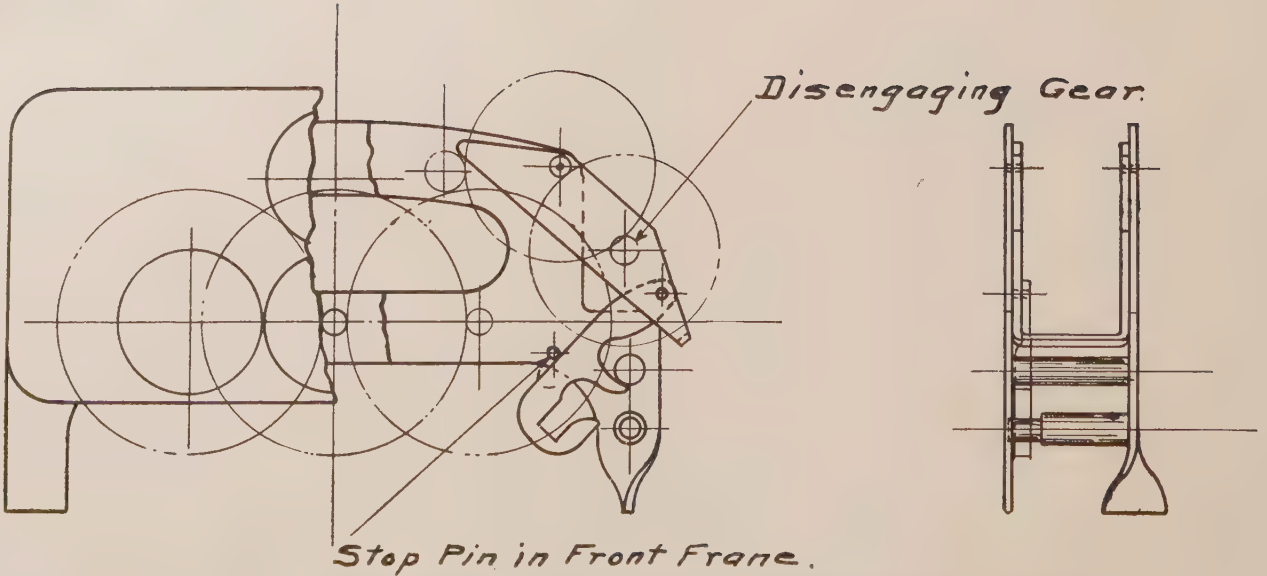
W. K. HARRINGTON,
Genl. Supt. Meters, Consolidated Gas Co. of New York.
Ill. Nos. 49 and 49A.



Ill. No. 48.—Gearing for Reducing Lost Motion.



Ill. No. 49.—Adjustable Index. Index shown closed.



Ill. No. 49A.—Adjustable Index. Index shown open, with dial plate and front frame removed.

METER INSPECTION FORM.

The accompanying cut shows the form used by a special inspector who visits all new sets within a few days after they are made. The cut of the meter on the back enables him to illustrate graphically the location of any trouble.

DETROIT CITY GAS COMPANY.

Ill. No. 50.

KEY BADGE.

All District Men carry a key ring badge, a copy of which is shown in the illustration. Since this badge has been in operation the number of keys lost has been noticeably reduced.

W. K. HARRINGTON,
Genl. Supt. Meters, Consolidated Gas Co. of New York.

Ill. No. 51.

AUTOMATIC OILING DEVICE FOR DIPPING METERS.

The accompanying sketch shows an accurate, rapid, and cleanly way of measuring out a predetermined quantity of oil and injecting it into the diaphragm chambers of meters. The oil tank "A" is connected at the bottom to a 3-way cock "B" and at the top to an air pressure line although it may be only vented to the atmosphere. The air pressure line "C" is also connected by means of small brass tubing to the measuring chamber "D." The bottom of the measuring chamber is connected with the 3-way cock "B." From the lower opening of the cock is suspended a short piece of flexible tubing with a nozzle inserted in the end capable of being inserted into a small hole punched through the side of the meter. A detail of the measuring chamber is shown at the right. The distance the small brass tube projects into the cylinder determines the amount of oil that the apparatus will deliver. In operation when the cock is thrown one way, the chamber fills with oil up to the bottom of the brass tube and when the cock

METER SET INSPECTION

Address .....

Name .....

Any leak about Meter?.....
(Indicate on back the location)

Is meter properly set?.....

Is location of meter good?.....

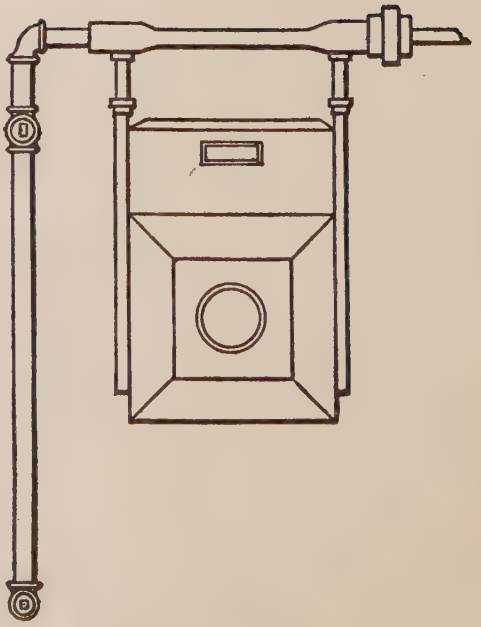
Remarks.....

.....

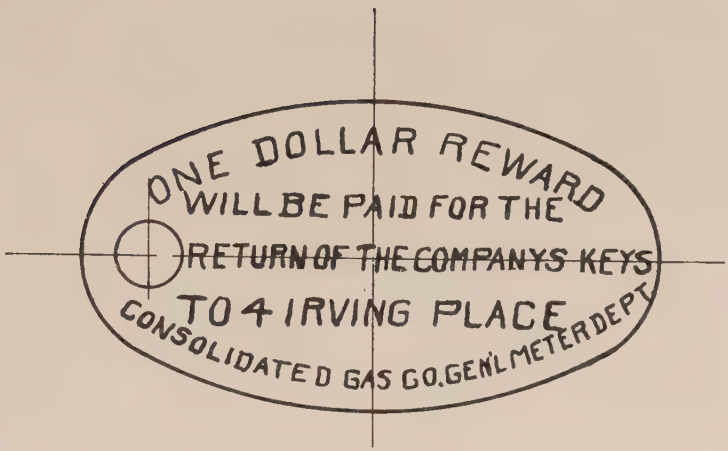
.....Lt.....Index.....OO.....

Executed.....190...Time.....M

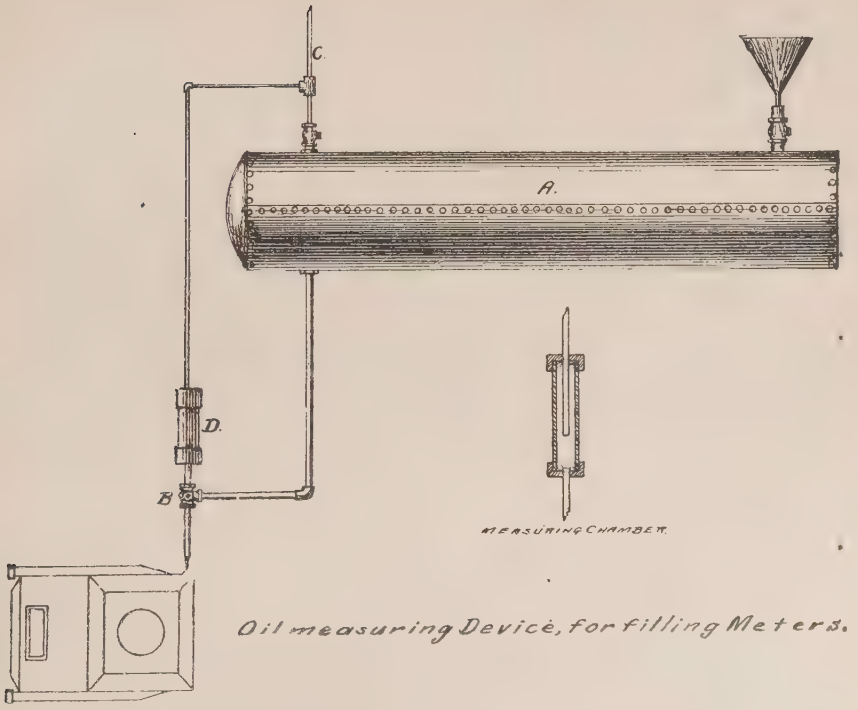
Employee.....



Ill. No. 50.



Ill. No. 51.—Key Ring Tag.



Ill. No. 52.

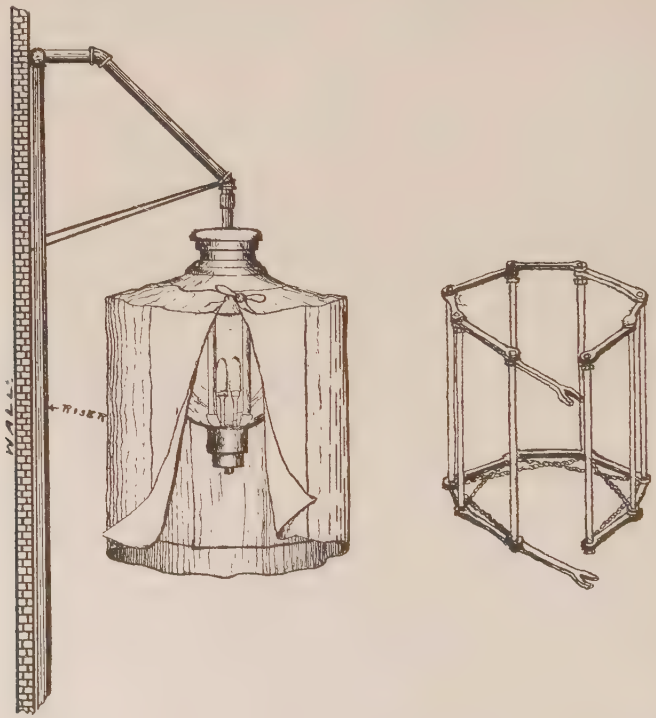
is reversed the oil is forced rapidly into the meter by the air pressure from above. As many measuring chambers can be installed on one oil tank as desired. The error due to the variation of the height of oil in the small brass tube will be less than 1% in most cases.

DETROIT CITY GAS COMPANY.

Ill. No. 52.

FOLDING WIND SHIELD FOR ARC LIGHTS.

The accompanying sketch shows a folding wind shield for



Ill. No. 53.—Wind Shield for Arc Lights.

use in taking care of outside arc lights. The shield consists of a jointed steel wire frame covered with cloth. At the lower end of the frame each panel is tied with chains across

to the second panel from it in rotation. These flexible cross ties will allow the shield to fold inward into a flat bundle, but will hold it rigidly in an octagonal shape when opened up. The cloth cover extends 6" above the frame and a heavy cord run through the hem is used in hanging the shield onto the arc as shown in the sketch.

DETROIT CITY GAS COMPANY.

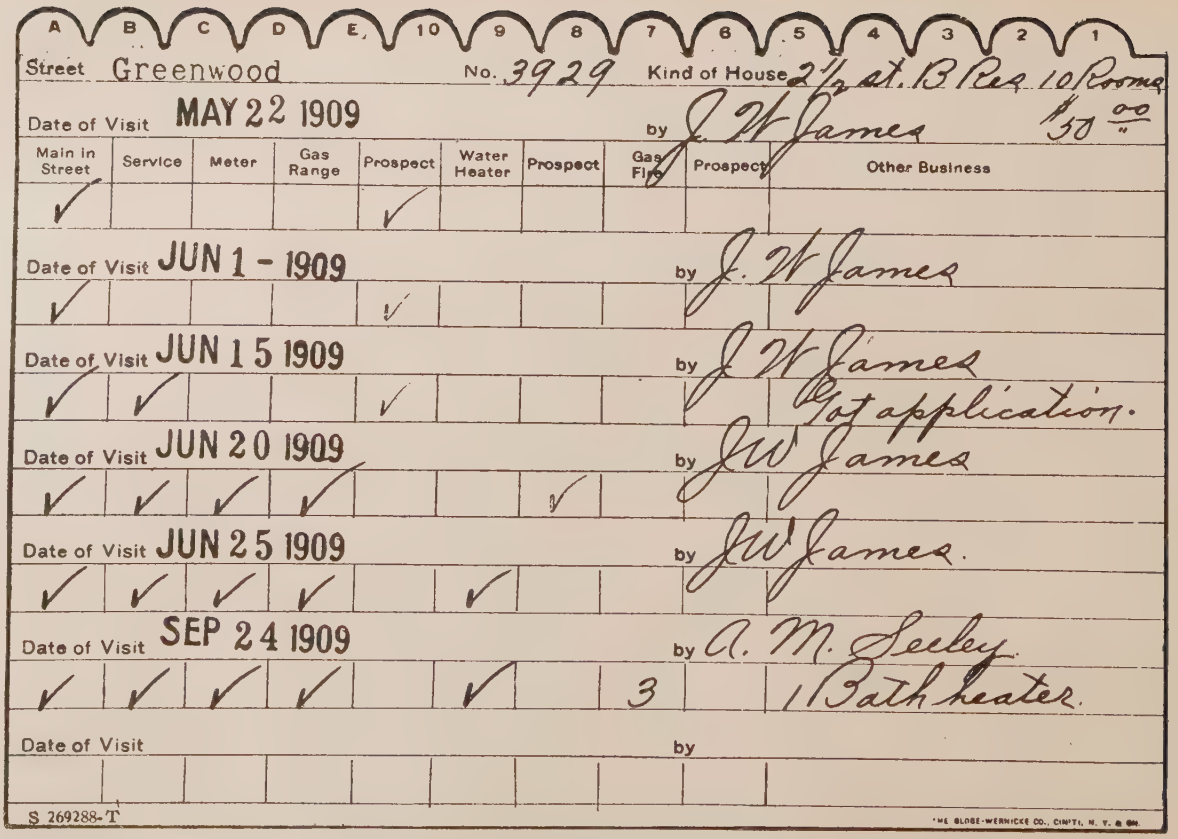
Ill. No. 53.

CARD FOR NEW BUSINESS DEPARTMENT.

The accompanying cut shows a form of card which we use for seeking new business and keeping up with the condition of service in each house. On the back of the second card is a key to the meaning of tabs on the first card. You will observe that the tabs at one end, A, B, C, D, E, represent the character of the house, expressed in the number of dollars per month for which it will probably rent. The house I am sending rents for $50.00 per month, so tabs A, B and C would be cut off, and D left on. At the beginning there is a main in the street and no service. Tab No. 1 is cut off. After the second or third visit we get in a service and a meter; Tabs No. 2 and No. 3 are cut off. On the fourth and fifth visit a gas range is sold and a water heater installed. Tabs 4 and 5 are cut off, and so on until the house has every character of service which we are prepared to furnish, and the eight tabs on the right hand side are cut off.

These cards are placed in drawers arranged by streets and numbers. If it is desired to send out canvassers to push water heaters, the eye can see at a glance every house which has a main and a service and no water heater. That is, Tab No. 5 would still be on the card. By looking at the other end of the card it can be determined whether or not the house is of such a character that the occupants can probably afford a water heater.

You will see that with this system worked out and kept up to date, every scrap of information which is brought into the



Street Greenwood No. 3929 Kind of House 2½ st. B Res. 10 Rooms

Date of Visit MAY 22 1909 by J. W James $30 00

Main in Street	Service	Meter	Gas Range	Prospect	Water Heater	Prospect	Gas Fire	Prospect	Other Business
✓				✓					

Date of Visit JUN 1 - 1909 by J. W James

✓				✓					

Date of Visit JUN 15 1909 by J W James

✓	✓			✓					Got application.

Date of Visit JUN 20 1909 by J W James

✓	✓	✓	✓			✓			

Date of Visit JUN 25 1909 by J W James.

✓	✓	✓	✓		✓				

Date of Visit SEP 24 1909 by A. M. Seeley.

✓	✓	✓	✓		✓		3		1 Bath heater.

Date of Visit by

S 269288-T

THE GLOBE-WERNICKE CO., CINTI, N. Y. & CHI.

792

Ill. No. 54.

office by the canvassers is preserved in shape to be used by any future canvassers, and by glancing over the cards representing any street, the exact condition of that street as a place in which to seek new business is at once apparent.

DONALD MCDONALD,
Prest., Kentucky Heating Co., Louisville, Ky.

Ill. No. 54.

GAS "FOOT LIGHT" SYSTEM INSTALLED IN SIDE WALL OF SALES ROOM FOR SHOWING LAMPS AND GLASSWARE.

All piping is concealed with only the brackets, lamps, and wheels of the valves showing.

The valve in the main line M is used to turn the system off each night. The valves A A are so adjusted that with one short turn to the left all the gas will be shut off except enough passing through the by-pass valves B B to keep a fair-sized pilot light going in each lamp.

A turn to the right with the valves A A will instantly light up the whole line of glassware. We use on each line of piping twenty-four lamps which gives us a fine assortment of lamps and glassware to show with no more than a turn of a valve.

GRAND RAPIDS GAS LIGHT CO.

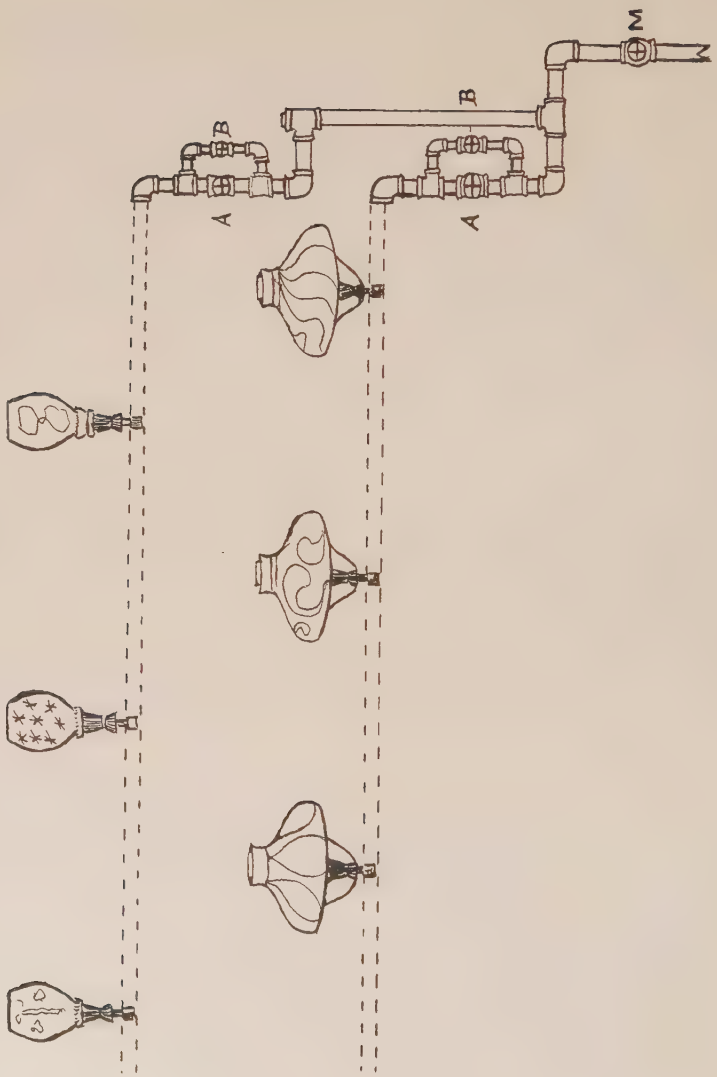
Ill. No. 55.

USE OF GAS FOR HEATING ASPHALTUM TANKS.

We have recently made installation of gas burners under a tank to be used for heating asphaltum, in which steel pipe is dipped. This tank is 35 feet long, 3 feet deep, and 3 feet wide, the pit being concave in shape.

The installation consists of seven special burners, which have a capacity of 1400 ft. per hour. These burners are used in full capacity for from three to four hours, to bring the asphaltum to a boiling point, and then the consumption is cut down to about 800 feet.

This displaces the use of wood as a means of heating, and



Ill. No. 55.

we not only make a saving over other fuels, but also a saving on the cost of labor, and lessen the danger of fire. When using wood, the work required the services of two men, one man to fire and the other to watch the tank; with the present arrangement, one man supplies all the necessary labor, consequently making a saving of one man's time.

G. S. Pearson,
Denver Gas and Electric Co.

The Grand Rapids Gas Light Company place a sticker, printed as follows:—

> "You will notice that the period covered by the meter readings from which this bill is made, is for more than the regular 30 day month."

to every gas bill that is for more than a month's consumption, and it keeps down the complaints from consumers who would not, without it, notice the fact that the larger bill is due to irregular times of taking statements.

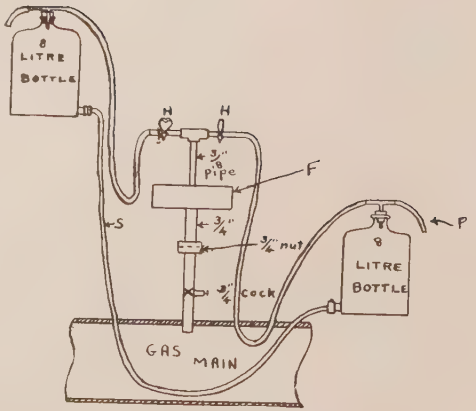
METHOD OF DETERMINING TAR IN GAS.

The accompanying sketch is of a device for determining the relative quantities of tar which are carried by gas.

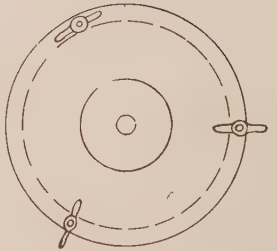
The sketch shows clearly the apparatus and method, the gas being drawn from the gas main through filter papers into bottles which furnish means of measuring the quantity of gas passed through the filter papers. A meter may, of course, be substituted for the bottles. Comparative tests on equal quantities of gas will show clearly the relative quantities of tarry matter carried.

W. S. Blauvelt,
Supt., Coke Oven Dept., Solvay Process Co., Detroit, Mich.

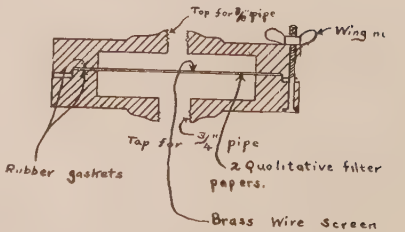
Ill. No. 56.



F = Wood filter frame
H = 3/8" Hose cocks
P = Pinch cocks
S = Screw pinch cock.



A. F. HERSTING.



DETAIL OF FILTER FRAME "F"

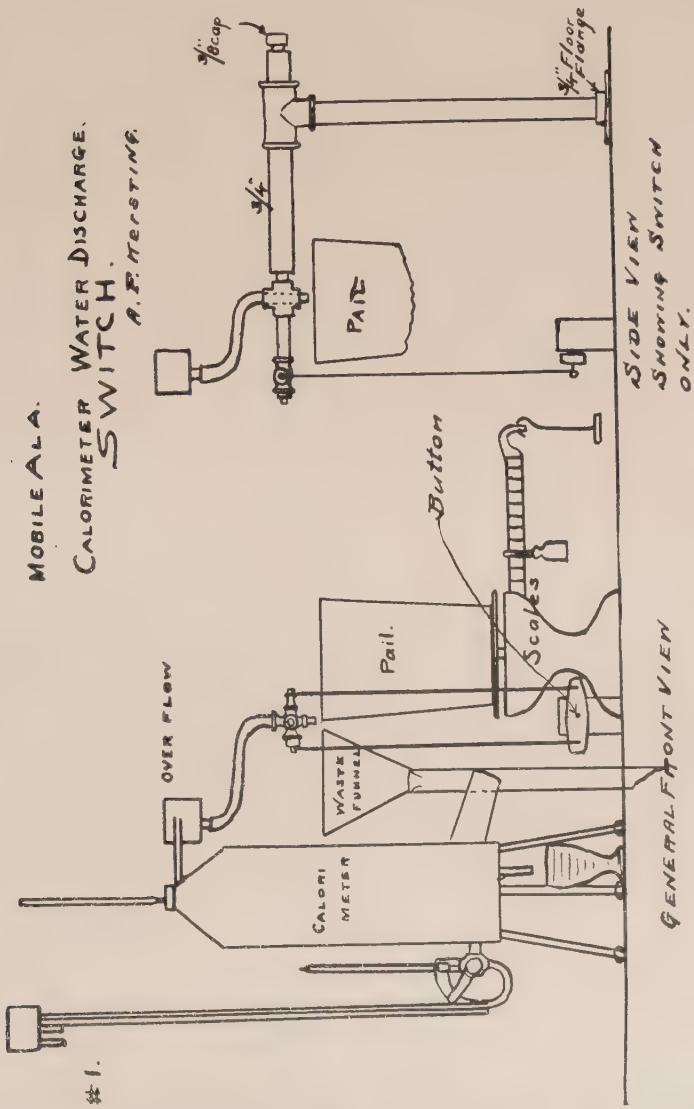
APPARATUS FOR DETECTION OF TAR IN GAS.

8 - 19 - 09

Ill. No. 56.

METHOD OF OPERATING JUNKERS CALORIMETER.

The accompanying sketch illustrates a device for the in-



Ill. No. 57.

stantaneous switching of the discharge water from Junkers

Calorimeter, and as per sketch is arranged so that the rubber tubing from the overflow passes through a 3/8" cross which is made into a 3/8" pipe, in turn being supported inside of a 3/4" pipe; two cords are attached to the plug screwed into a second 3/8" cross and the opposite ends to a wooden button fastened to the table. The operator is able to pay minute attention to the meter dial and secures a positive switch of the discharge, without waste, exactly at any desired reading of the meter. Our burner is adjusted to about seven feet per hour. Five readings of the water thermometers are taken during the consumption of 2/10ths of a foot, the water being adjusted to run about seven pounds during this time. Two complete determinations are made on a single test, and the difference in water used is never greater than two-hundredths of a pound.

A. F. KERSTING,
Supt., Mobile Gas Co., Mobile, Ala.

Ill. No. 57.

NOTE FROM THE SECRETARY OF THE TRUSTEES GAS EDUCATIONAL FUND.

All question and answers sent out to the members of the Practical Class during the year have been previously published, and can be found in Volume 1, of the Proceedings.

ALFRED E. FORSTALL,
Secretary.

CONSTITUTION AND BY-LAWS

OF THE

American Gas Institute.

Constitution.

NAME.

SECTION 1. The name of this association shall be the AMERICAN GAS INSTITUTE.

OBJECTS.

SECTION 2. The objects of this Institute are to amalgamate into one body the American Gas Light Association, the Ohio Gas Light Association, and the Western Gas Association, and to facilitate co-operation between the various state and district associations that now exist, or may here after be formed within the territory covered, and to secure thereby the more rapid promotion and advancement of scientific and practical knowledge in all matters relating to the construction and management of gas works and the manufacture, distribution and consumption of gas; the firmer establishment and maintenance of a spirit of fraternity between those interested in the gas business by affording opportunity for social intercourse and friendly interchange of information and ideas; the inducement and extension of more cordial and friendly relations between gas companies and consumers of gas based upon their mutual interests, and the education of employees of gas companies to enable them to better perform their duties. Also

to take over such property and assets of the associations named as may be legally invested in the Institute.

MEMBERS.

SECTION 3. The membership of the Institute shall consist of Honorary Members, Active Members, Junior Members and Associate Members. Honorary Members, Junior Members and Associate Members shall not be entitled to vote nor to hold office, but shall be entitled to all the other privileges of membership.

SECTION 4. Honorary Members shall be persons whose scientific or practical knowledge in matters relating to the gas industry, and whose efforts and interests in that behalf shall recommend them to the Institute.

SECTION 5. To be eligible to Active Membership, a person must be at least 26 years of age, and be an officer or other employee of a Gas Company; or a Consulting Gas Engineer, or an employee of a Consulting Gas Engineer. He must be competent to act efficiently as the Manager of a department of a Gas Company's business and must have his chief interest in the gas business directly connected with the manufacture, sale, or utilization of gas, and not the manufacture or sale of apparatus or appliances used by Gas Companies.

SECTION 6. To be eligible as a Junior Member, a person must be over 20 years of age and be in the employ of a Gas Company, or of a Consulting Gas Engineer, and must be qualified either by experience or education to hold a responsible position under such employers.

SECTION 7. To be eligible as an Associate Member, a person must be engaged in a pursuit which constitutes a branch of gas engineering, or be otherwise qualified to assist in promoting the objects of the Institute.

SECTION 8. Charter Members shall be such of the present membership of the American, Ohio, or Western Gas Association as shall be certified by the officers of the same to the Directors of the Institute as qualified respectively for Active, Junior or Associate membership, provided that to become a charter member, it shall be necessary for each person so certified to make application to the Directors of the Institute within a period of sixty days after notice has been sent him of the formation of the Institute.

ELECTION OF NEW MEMBERS.

SECTION 9. Honorary Members shall be proposed by the Directors to the members of the Institute by mailed notifications immediately after any annual meeting, and shall be voted upon by letter ballot at the time of the regular September ballot next following.

SECTION 10. Every application for either Active, Junior or Associate Membership shall be made to the Secretary in writing upon a form approved by the Directors, upon which shall be set forth as the grounds of the application a complete account of the qualifications and experience of the applicant and his agreement to conform, if elected, to the Constitution, By-Laws and Rules of the Institute, and shall be endorsed by at least two Active Members to whom the applicant is personally known. The Secretary shall submit each application to the Directors, who shall consider and act upon it and assign the applicant to the grade of membership to which, in their judgment, his qualifications entitle him. The name of each candidate thus approved by the Directors shall, unless objection is made by the applicant, be submitted to the voting membership for election by means of a letter ballot.

SECTION 11. It shall be competent for any Junior or Associate member to apply for transfer to another grade of membership. The application for such transfer shall be made in the same manner as in the case of a new applicant.

SECTION 12. Election to membership shall be by a sealed letter ballot, as the By-Laws shall provide, Adverse votes to the number of 2 per cent. of the votes cast shall be required to defeat the election of an applicant for any grade of membership. The Directors may, in their discretion, order a second ballot upon a defeated applicant, in which case adverse votes to the number of 4 per cent. of the votes cast shall be required to defeat the election.

SECTION 13. Any person elected to the Institute, except Honorary Members, must subscribe to the Constitution and pay to the Treasurer the initiation fee and one year's dues for his grade of membership before he can be entitled to the rights and privileges, or can receive a certificate of membership. If this requirement is not complied with within six months of the notification of the election the applicant will be deemed to have declined the election and the election shall be void.

INITIATION FEES AND DUES.

SECTION 14. The initiation fee for membership in each grade shall be as follows:

For Active Members	$15.00
For Associate Members	15.00
For Junior Members	5.00

These initiation fees shall not include the dues for the current year in which the applicant is elected.

SECTION 15. A Junior Member, on promotion to any other grade of membership, shall pay an additional fee of $10.00, except that Charter Junior Members shall not be required to pay such additional fee. No person shall retain Junior membership for more than two years after becoming qualified for active membership.

SECTION 16. The annual dues, payable in advance, for membership in each grade shall be as follows:

For Active Members	$10.00
For Associate Members	10.00
For Junior Members	5.00

SECTION 17. The Directors may in their discretion permit any Active or Associate Member to become a Life Member in the same grade by the payment in one sum of an amount sufficient to purchase from a reputable life insurance company an annuity on the life of a person of the age of the applicant equal to the annual dues in his grade of membership. Such life member shall not be liable thereafter for annual dues. Life members of the associations dissolving shall only be required to pay the difference, if any, between the sum computed as above and that already paid for their present life membership.

SECTION 18. The Directors shall have power by letter ballot to admit to Life Membership, without the payment of a life membership fee, any person who for a long term of years has been an active or an associate member, when, for special reasons, such an action would, in their judgment, promote the best interests of the Institute. Notice that such action as proposed shall have been given at a previous meeting of the Directors, and one dissenting vote shall defeat the proposed action.

SUSPENSIONS AND EXPULSIONS.

SECTION 19. A member whose dues for a year completely expired are not paid, shall not be entitled to vote, nor to participate in the deliberations of the Institute, nor to receive a copy of the proceedings. Any member whose dues shall remain unpaid for a term of three years may be dropped from the roll of membership by a vote of the Directors. A member

dropped for non-payment of dues may upon paying the amount he owes the Institute, be reinstated at the option of the Directors.

SECTION 20. The Directors may refuse to receive the dues of any member of any grade who shall have been adjudged by them to have violated the Constitution or By-Laws of the Institute, or who, in their opinion, shall have been guilty of conduct rendering him unfit to continue in its membership, and such person may be expelled from the Institute upon a recommendation to that effect made by the Directors at any general meeting of the Institute. The vote upon expulsion shall be by ballot and shall require two-thirds of the votes cast for its adoption.

SECTION 21. The Directors may transfer any member from his then present to any lower grade of membership. They may also refuse to receive the dues of any member who is no longer eligible to any grade. No transfer of grade shall be made, or refusal to accept dues recorded, except upon notice from the Secretary, whose duty it shall be to give such notice, that said member is no longer eligible for membership in his then present grade, and that said member has for a period of ninety days after notification of such non-eligibility, failed to apply for transfer. The vote in each case shall be by ballot, and shall require two-thirds of the votes cast for its adoption.

MANAGEMENT.

SECTION 22. The affairs of the Institute shall be managed by the Directors, subject to the control of the general meeting.

SECTION 23. The Board of Directors shall consist of the President, the two Vice-Presidents, the Secretary, the Treasurer, the Junior Past-President, and until changed as hereinafter provided for, ten Active Members of the Institute. Five members shall constitute a quorum for the transaction of business. If arrangements are made for co-operation between

the Institute and district and state gas associations, as hereinafter provided for, the number of members of the Board elected from the Active Members of the Institute shall be increased from time to time, as it becomes necessary, in order to keep the number of Directors elected by the Institute equal to not less than two-thirds of the total number of both Institute and Associate Directors.

SECTION 24. Should a vacancy occur in the Board of Directors or in any elective office, except the Presidency or First Vice-Presidency, through death, resignation or other cause, the Directors may elect an Active Member to fill the vacancy until the next annual election.

SECTION 25. The Directors shall regulate their own proceedings, and may, by resolution, delegate specific powers to an Executive Committee, or to any one or more of their members. No act of the Executive Committee, or of a delegate, shall be binding until it has been approved by a resolution of the Directors.

SECTION 26. The Board of Directors shall present at the annual meeting of the Institute a report verified by the President, Secretary and Treasurer, or by a majority of the members which shall show the state of the finances of the Institute at the date of the report; the receipts and expenditures for the fiscal year immediately preceding; the names and places of residence of the persons who have been admitted to membership in the Institute during that year, and give an account of the action taken by the Directors upon matters coming before it and recommendations as to the action to be taken by the Institute. This report shall be filed with the records of the Institute and an abstract of it shall be entered in the minutes of the proceedings of the annual meeting.

OFFICERS.

SECTION 27. At each annual meeting there shall be elected from among the Active Members a President, two Vice-Presi-

dents, a Secretary, a Treasurer, and until otherwise provided for, five members of the Board of Directors. All of the officers shall be elected for one year, but the members of the Board of Directors shall be elected for two years. At the first general meeting ten members of the Board of Directors shall be elected, five to hold office for one year and five to hold office for two years.

SECTION 28. All elections shall be by ballot.

SECTION 29. The term of all elected officers shall begin on the adjournment of the annual meeting of the Institute at which they were elected. Officers shall continue in their respective offices until their successors have been elected and have accepted such election.

SECTION 30. The President and the retiring Active Members of the Board of Directors shall not be eligible for reelection the following year.

SECTION 31. Previous to each annual meeting it shall be the duty of the Directors to appoint a nominating committee of five members, none of whom shall be a Director. It will be the duty of this nominating committee to present at the annual meeting a list of the Active Members and Directors whom they recommend as officers for the ensuing year.

SECTION 32. Twenty or more members entitled to vote may constitute themselves a special nominating committee with the same powers as the nominating committee appointed by the Directors.

SECTION 33. The Directors shall appoint from their own number immediately after the meeting at which they are elected a finance committee of three members.

SECTION 34. The President shall take the chair at all meetings of the Institute, of the Board of Directors and of committees at which he is present. He shall determine to which general committee any matter shall be referred.

SECTION 35. In the absence of the President one of the Vice-Presidents shall take the chair, and in the absence of the President and Vice-Presidents a Chairman shall be appointed by the Directors from among their own members.

SECTION 36. The duties of the Secretary shall be to take minutes of all proceedings of the Institute and of the Board of Directors, and to enter them in proper books for that purpose. He shall conduct the correspondence of the Institute, read minutes and notices of all the meetings, and also such papers and communications as are considered in the absence of their authors, and perform whatever other duties may be required in the Constitution and By-Laws appertaining to this department.

SECTION 37. The duties of the Treasurer shall be to receive and keep all annual dues and funds of the Institute, to keep correct accounts of same, and pay all bills approved by the President and a member of the Finance Committee, and he shall make an annual report to be submitted to the Institute.

SECTION 38. The duties of the Finance Committee shall be to audit the books, accounts and statements of the Treasurer; to invest the funds of the Institute, and to care generally for the finances of the Institute, subject to the control of the Directors.

SECTION 39. The duties of the Directors shall be to have the general management of the affairs of the Institute, and to prepare for its meetings. No paper or report that has not had the approval of the Directors shall be read at any meeting.

The Directors shall have the power to appoint, from time to time, a Committee on Arrangements from among the members to assist the Board of Directors in arranging for the meetings of the Institute. The Directors shall have power to fill for the unexpired term, any vacancies occurring by death, or resignation, in their own number, or in the general committees.

Any resolution, report or recommendation, that has not been considered and approved by the Directors, and that in the opinion of the Chair would have the effect of changing the policy of the Institute, or committing it to any new policy or opinion to which it had not theretofore been committed, should be referred, before adoption, to the Board of Directors, whose duty it shall be to report to the next regular meeting of the Institute upon such committal, if any, and its proper phrasing.

SECTION 40. There shall be two general committees, each reporting to the Board of Directors and responsible to the Board for such part of the work of the Institute as is delegated to it in accordance with the provisions of Sections 34, 41 and 42. Each committee shall be composed of six members, to be appointed each year by the President, and to serve one year.

SECTION 41. One general committee shall be called the Public Relations Committee, and to it shall be referred all investigations, reports, recommendations, resolutions and matters of any kind affecting the relations between the Institute, or its members, and the public, or any governing bodies, except as herein provided.

SECTION 42. One general committee shall be called the Technical Committee, and to it shall be referred all investigations, reports, recommendations, resolutions and matters of any kind having to do with the construction, operations and extension of gas works, and the conduct of the affairs of gas companies, not specifically delegated to the Public Relations Committee by Section 41, and except as herein otherwise provided.

SECTION 43. Each general committee shall have the power to appoint sub-committees. Each sub-committee shall consist of one member of the general committee, the other members being taken from the general membership of the Institute, and shall exist at the pleasure of the general committee by which it was appointed, and to which its report shall be made

MEETINGS AND PROCEEDINGS.

SECTION 44. The annual meeting of the Institute shall be held on the third Wednesday of October of each year, at such place as shall be designated by the Institute at the previous meeting. In case of emergency the Directors shall have the power to change the time or place of meeting, or both, as so designated, by a three-fourths vote of all its members, at the call of the President, and such vote may be taken by mail.

SECTION 45. The Secretary shall send notices to all members of the Institute at least fourteen days before each general meeting, mentioning the papers to be read and any special business to be brought before the meeting.

SECTION 46. Special meetings of the Institute may be called at the option of the Directors, and the Secretary shall call a special meeting on the written request of one hundred members.

The notices for special meetings shall be sent to all members at least three weeks before the date for which the meeting is called and shall state the business to be transacted, and no other shall be entertained.

SECTION 47. Thirteen members shall constitute a quorum.

SECTION 48. All questions, except as otherwise provided in Sections 9, 20, 28, 49 and 57, shall be decided by any convenient system of open voting, the presiding officer to have a second or casting vote when necessary.

SECTION 49. Questions of a personal nature shall be decided by ballot, and all parliamentary procedure not specifically covered by this Constitution shall be governed in accordance with Robert's Rules of Order.

SECTION 50. Any member, with the concurrence of the presiding officer, may admit a friend to each meeting of the Institute but such person shall not take part in any of the discussions, unless permission to do so be given by the meeting.

SECTION 51. All papers read at the meetings of the Institute must relate to matters, either directly or indirectly connected with the objects of the Institute, and must be approved by the Directors before being read.

SECTION 52. All papers, drawings or models submitted to the meetings of the Institute shall be and remain the property of the authors.

SECTION 53. The President, the Junior Past-President, the First Vice-President, the Junior Past-Chairmen of the two general committees, and the Secretary shall constitute a Publication Committee, and nothing shall be included in the published reports of the Institute's Proceedings, or in any other publication issued by its authority, that has not been approved by at least two-thirds of the full membership of the Publication Committee.

SECTION 54. The Directors shall meet the day before each general meeting of the Institute, and also on such day between June 1st and September 15th, both inclusive, as may be designated by the President by notice given at least one week in advance of meeting. Special meetings may be called when the President shall deem it necessary, and the President shall be required to call a special meeting at any time on the written request of five members of the Board. Of such meetings reasonable notice shall be given by special call, in print or writing, specifying the business to be attended to.

AFFILIATION WITH LOCAL ASSOCIATIONS.

SECTION 55. The Board of Directors may in its discretion make with any one (or each) of the district and state gas, or gas and electric, associations now existing or hereafter to be formed, agreements for co-operation between the Institute and such associations. Each and every such association with which such agreements are entered into, shall covenant as follows: Not to elect to voting membership any person con-

nected in any way with the gas industry, who is not directly identified with gas, or electric interests, within the state or district designated by the name of the association; and to consult with the Institute before undertaking any original work of interest to the gas profession. All original work carried on by an affiliated association under this agreement shall, when completed and accepted by that association, be presented to the Institute for approval, and when so approved shall be incorporated in the Proceedings of the Institute in such form as the Directors shall determine. Each and every such association shall during the continuance of such agreements, be entitled to elect one of its members a member of the Board of Directors of the Institute, the members so elected to be in addition to those named in Section 23, provided that the number of such associated Directors shall never exceed one-third of the total membership of the Board. Should the Board of Directors provide for an executive committee, this committee shall include in its membership one man from each of the affiliated associations as long as the number of such associations does not exceed six. Thereafter there shall be on the executive committee at least six men who are members of affiliated associations and have among them membership in at least six such associations.

PROCEEDINGS.

Section 56. Each member of the Institute in good standing shall be entitled to and shall be furnished by the Secretary with a copy of the Proceedings of the Institute for the current year, in which shall be listed the names and addresses of the members. In any such list each member should be listed by the title or titles, only, from which he derives his eligibility to his class of membership.

AMENDMENTS.

Section 57. All propositions for adding to or altering any of the provisions of the foregoing Constitution shall be laid

before the Directors, who, if they see fit, may bring it before the next general meeting of the Institute and who shall be bound to do so on the requisition in writing of any ten members of the Institute. All such propositions shall be decided by ballot and shall require two-thirds of the vote cast for their adoption.

By-Laws.

(Section numbers refer to corresponding Sections of the Constition.)

1. (SECTION 10.) Each member proposing a candidate for admission is required to make a confidential communication to the Secretary for forwarding to the Membership Committee, setting forth in detail such information, personally known to referee, as shall enable the Directors to decide upon the eligibility of the candidate for admission to the Institute, except that in the event of the requisite number of members in good standing having personally signed the application of a candidate, this may be deemed sufficient endorsement and the requirement of the confidential communication referred to above shall not be obligatory, but shall be optional at the discretion of the Membership Committee. The Secretary shall be the judge of the competency and the signature of referees.

2. (SECTION 10.) In the absence of replies from the referees to inquiries for information, or if replies are not sufficiently explicit, the Secretary shall cause the applicant to be notified, and the application shall be held in abeyance.

3. (SECTION 10.) Immediately after the meeting at which they are elected, the Directors shall appoint from among their own number a Membership Committee of five members. They shall pass on all applications for membership and report to the Directors. Any correspondence in regard to an applicant shall be destroyed when his name has been placed on the voting ballot, or upon withdrawal of the application.

4. (SECTION 12.) The Secretary shall, twice a year, on or about the first day of March and September, mail to each member entitled to vote, a ballot stating the names and respective grades of the candidates for membership in the Institute which have been approved by the Directors, and the time of the close of voting. The voter shall prepare his ballot by crossing out the names of candidates rejected by him, and shall enclose said ballot in a sealed blank ballot envelope, which

he shall then enclose in a second sealed outer envelope on which he shall, for identification, write his name in ink. The ballot thus prepared and enclosed shall be mailed or delivered unopened to the Secretary, which shall be counted as an affirmative vote on all the names not crossed out. The Secretary shall be the judge of the competency and the signature of all voters. On the close of the voting, the Secretary shall first open and destroy the outer envelopes, and shall then canvass the ballots, and certify the result to the Membership Committee.

The Secretary shall not receive any ballot after the stated time of the close of voting. A ballot without the endorsement of the voter, written in ink on the outer envelope, shall be considered as defective, and rejected by the Secretary.

The names of those persons elected to membership, with their respective grades, shall be embodied in a written report, signed by the Secretary, and presented to the next meeting of the Institute. The President shall then declare them duly elected to membership in the Institute. The Secretary may, in advance of any meeting, advise each candidate of the result of the canvass of the votes in his case. The names of applicants who are not elected shall neither be announced nor recorded in the Proceedings.

The endorser of an applicant who has not been elected, may, with his consent, present to the Directors a written request for a re-submission of his name to ballot. The Directors may, in their discretion, by three-fourths vote of the members present, order the name of the applicant placed on the next ballot for members.

5. (Section 13.) Section 13 of the Constitution shall be printed upon the notification of election to all members except Honorary Members.

6. (Sections 14 and 16). The initiation fee and annual dues of the first year shall be due and payable on notice of

election to membership. Bills for the fee and dues should accompany the notification of election. Thereafter the annual dues shall be due and payable on the first day of October of each year.

7. (Sections 14 and 16.) Upon payment of the initiation fee and annual dues, a newly elected member shall receive a copy of the volume of the proceedings containing the report of the meeting held in the then current fiscal year, and copies of any other publications of the Institute, which may have been distributed without charge to the members during that year, even though the date of issue of these publications is prior to that of the election of such member.

8. Each member shall be entitled to a badge upon payment of an amount to be fixed from time to time by the Directors. Upon his ceasing to be a member, he shall return his badge, and receive therefor the sum of $2.00.

9. Each member shall be entitled to a certificate of membership in accordance with his grade, signed by the President and Secretary. Every such certificate *shall remain the property of the Institute* and shall be returned to the Secretary on demand of the Directors.

10. (Section 19.) The Treasurer shall present to the Directors the name of any member in arrears for more than one year.

11. (Section 26.) The Secretary shall furnish the Directors with the information needed for their annual report, excepting only as to finances, or to matters which have been entrusted to special committees. The financial report shall be made by the Treasurer to the Finance Committee.

12. (Section 26.) The fiscal year of the Institute shall begin September 1st.

13. (Section 28.) The President shall, at the first session of the Annual Meeting, appoint three Tellers of Election,

who shall canvass the vote cast for officers, and report the result to the meeting.

14. (Section 31.) The Nominating Committee shall report at the first session, and a ballot be taken on their report at once, unless twenty or more members object. In such case, the ballot for officers shall take place at the first session of the second day, in the manner prescribed in By-Law No. 15.

15. (Section 31.) If the report of the Nominating Committee is not unanimously adopted, the Tellers of Election shall distribute ballots among the members, at once, unless the election is postponed as covered by By-Law No. 14. In either case poll may be opened outside the meeting room in some adjacent and convenient place. If there is no objection, one ballot may be cast for those nominated by the committee.

16. (Section 33.) When the appointment of a chairman is not included in the appointment of a committee, the latter shall elect their own chairman.

17. (Section 36.) The Secretary shall be in charge of the membership lists. He shall also be in charge of all other property of the Institute not distinctly pertaining to the Treasurer's work.

18. (Section 37.) The annual report of the Treasurer shall be embodied in the financial report of the Directors.

19. (Section 37). Neither the Treasurer nor any other officer of the Institute shall pay out money except upon bills approved by the President and a member of the Finance Committee.

20. (Section 37.) The Treasurer shall furnish a bond for the faithful performance of his duties to such amount as the Finance Committee may require, such bond to be procured from an incorporated guarantee company at the expense of the Institute.

21. (SECTION 39.) The President, subject to subsequent approval by the Directors, may, in his discretion, appoint a member or members of the Institute to represent it at meetings of Associations of kindred aim or at public functions. Such delegates should be designated as "Honorary Vice-Presidents," and their duties shall terminate with the occasion for which they are appointed.

22. (SECTION 39.) Not later than six months prior to each annual meeting of the Institute, the Directors shall appoint an Arrangement Committee to have charge of all the details connected with the annual meeting, except only as to papers.

23. At the opening of the first session, following the election of officers, the President shall appoint a committee of three to recommend the place to be designated by the Institute for the next annual meeting.

24. (SECTION 55.) Upon receipt of official notice from any district or state gas, or gas and electric association, of a desire to affiliate with the Institute and comply with the provisions of Section 55 of the Constitution, the Directors shall authorize the President and Secretary to execute an agreement with such district association. Upon execution of such agreement, the person designated by the district association as its representative on the Board of Directors, will be recognized as a member of such board to continue in office until his successor is appointed by the district association; or until the agreement is cancelled.

25. (SECTION 57.) Amendments of, or additions to, the By-Laws may be adopted by the Directors by a unanimous vote at any meeting. When objection is made, two weeks' notice and copy of the proposed changes shall be sent to each Director. At any meeting subsequent to such notice, a two-thirds vote will be sufficient for adoption.

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1909-1910.

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Engineer, Welsbach Street Lighting Company of America, N. W. Corner Broad and Arch Streets, Philadelphia, Pennsylvania.

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WHITFIELD, ALBERT.
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WILMOT, JAS. EDW.
Mfgr. and Salesman, Gas Tip and Self-Lighter Company, 149 Church Street, New York, New York.

WILSHIRE, FRANK W.
General Manager of Sales, Fairmont Coal Company, 1 Broadway, New York, New York.

WILSON, EDWARDS F.
Chemist, Irwin, Westmoreland County, Pennsylvania.

WOOD, EDWARD R., JR.
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YOUNG, N. A.
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ZITZEWITZ, HERMANN.
President, National Machine Works, 10 Sheffield Avenue, Chicago, Illinois.

ZWISLER, A. L.
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Total Associate Members 244

JUNIOR MEMBERS.

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Barnes, H. L.
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Beebe, Thomas Russell.
Manager, Stove and Natural Gas Department, The Peoples Gas Light & Coke Company, 155 Michigan Avenue, Chicago, Illinois.

Beers, Daniel N.
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FANCY, RAYMOND ASHLEY.
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FITZPATRICK, DAN.
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Houston, Gray Jones.
Foreman of Works, San Antonio Gas & Electric Company, San Antonio, Texas.

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Superintendent of Commercial Department, Spokane Falls Gas Company, Spokane, Washington.

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Zook, Samuel Kurtz.
Engineer, Bergen Division, Gas Department, Public Service Gas Company, 114 Main Street, Hackensack, New Jersey.

Total Junior Members 106

SUMMARY OF CLASSES OF MEMBERSHIP.

Active Members	982
Associate Members	244
Junior Members	106
Total	1332

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	A. H. Ford.
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	J. M. Ritson.
	Keating Lewis Simons.
Ensley	A. F. Hilleke.
Mobile	Albert F. Kersting.
Montgomery	L. A. Docteur.
	Chas. E. White.
Talladega	E. M. Osbourne.

Arkansas

Pine Bluff	B. C. Fowles.
	C. Bert Murdock.

California

Jackson	B. E. Letang.
Los Angeles	William Bauerhyte.
	Jos. M. Berkley.
	W. B. Cline.
	William J. Dorr.
	Frederick Charles Millard.
Pasadena	C. W. Koiner.
San Francisco	Joseph E. Aue.
	John A. Britton.
	Edward C. Jones.
	F. V. T. Lee.
	John Martin.
	C. O. G. Miller.
	Sam. L. Napthaly.
Santa Barbara	D. Elwood Keppelmann.
Stockton	Henry Eastland Adams.
Upland	Isaac C. Baxter.

Colorado

Boulder	F. W. Leland.
Canon City	William Bailey.
Colorado Springs	R. P. Bache.
	Ira Abbott Miller.
Denver	John T. Brady.
	C. K. Durbin.
	G. W. Faller.
	R. Garland Gentry.
	R. G. Griswold.
	M. E. Malone.
	E. W. Schaaf.
	Clare N. Stannard.
	A. F. Fraver.
	Edwin Wagner.
	Charles H. Williams.
Pueblo	W. A. Bertke.
	J. F. Klug.

Connecticut

Bridgeport	Chas. M. Gerdenier.
	Geo. W. Roberts.
	H. H. Sprague.
Derby	Charles H. Nettleton.
	George H. Scranton.
Hartford	H. L. Barnes.
	Guy K. Dustin.
	H. M. Harriman.
	B. Loomis.
Meriden	Charles A. Learned.
Milford	William Reeves.
New Haven	J. Arnold Norcross.
	F. C. Sherman.
	Robert E. Wyant.
New London	Alex. J. Campbell.
Rockville	William Morgan Lewis
Stamford	G. B. Leland.
	Henry J. Warren.
	John A. Waters.
Torrington	Frank M. Travis.
Waterbury	D. L. Summey.
	E. H. Williams.
Winsted	Rufus E. Holmes.

Delaware

Wilmington ..... R. H. Lawlor.
Harry S. Schutt.

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C. Clay Bayly.
Thomas J. Fisher.
William F. Hart.
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James S. McIlhenny.
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Jacksonville ..... Clarence S. Hammatt.
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Pensacola ..... Charles F. Zeek.
St. Augustine ..... Dan Fitzpatrick.
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George Old.

Georgia

Atlanta ..... P. S. Arkwright.
Richard C. Congdon.
F. B. Crowell.
A. D. Whittaker.
Columbus ..... MacDougald Dexter.
Macon ..... A. E. Boardman.
J. J. Cagney.
R. M. Redding.
Rome ..... James Ferrier.
Savannah ..... J. L. Cabell.
John W. Golden.

Illinois

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F. M. James.
B. O'Malley.
Henry L. Rice.
R. N. Strohn.
Belleville ..... Harry B. Kircher.
Bloomington ..... William F. Clausen.
Blue Island ..... Andrew McIntyre.

Illinois—(*Continued*)

Chicago .....Knowlton L. Ames.
Carl Asendorf.
Wm. A. Baehr.
C. Kemble Baldwin.
Wm. F. Barrett.
Wm. I. Battin.
Thomas R. Beebe.
A. Bement.
R. W. Bingham.
E. E. Brownell.
John C. Buckley.
F. S. Carnes.
Alfred A. Chichester.
John C. D. Clark.
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Edward G. Cowdery.
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James E. Davies.
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C. L. Day.
Edward A. Dieterle.
Alfred B. Eaton.
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Ralph Esau.
John H. Eustace.
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Albert L. Farr.
Russell S. Feurtado.
George P. Gilman, Jr.
John Ginley.
Alfred H. Gross.
H. D. Harper.
R. B. Harper.
A. S. Harrington.
William G. Henry.
H. R. Hunt.
Chas. W. Hunter.
William B. Jackson.
Benjamin J. Kellum.

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	Charles R. Lindsay, Jr.
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	N. A. McClary.
	G. W. McKee.
	Joseph Markley.
	William P. Martin.
	John A. Mason.
	Frank E. May.
	J. E. J. Mayer.
	Charles W. Melcher.
	Wensel Morava.
	Thomas N. Mordue.
	John M. Morehead.
	R. L. Morley.
	Edward E. Morrell.
	Manning A. Norland.
	George G. Olmstead.
	Otto E. Osthoff.
	W. J. Paleske.
	L. R. Phillips.
	Edward G. Pratt.
	Henry Pratt.
	Theo. V. Purcell.
	D. G. Ramsay.
	Irwin Rew.
	Rudolph Schenck.
	C. C. Schiller.
	E. E. Sidenstick.
	S. S. Stratton.
	W. D. Sweetman.
	Charles E. Ummachs.
	Albert Whitfield.
	John Williamson.
	Richard Williamson.
	William Wilson.
	W. R. Wones.
	E. L. Wortham.
	Herman Zitzewitz.
Chicago Heights	M. Morgans.
Decatur	John L. Busch.
	Robert Mueller.

Illinois—(*Continued*)

DeKalb	E. S. Davidson.
East St. Louis	Charles H. Quackenbush.
Elgin	Robert F. Fitz.
	C. B. Strohn.
Evanston	R. J. Jenks.
Freeport	Z. T. F. Runner.
Galena	J. B. Howard.
Galesburg	R A. McLaughlin.
Joliet	William E. Hartman.
	Heinrich Koppers.
Kankakee	F. E. Newberry.
Kewanee	Elmer W. Smith.
La Grange	George H. Dawson.
La Salle	H. E. Chubbuck.
Macomb	F. S. Armstrong.
North Chicago	J. A. Bower.
	W. S. Darley.
Oak Park	Charles W. Bradley.
	Mathias Britsch.
	Henry D. Schall.
	E. J. H. Wright.
Peoria	E. W. Eustace.
	J. M. Robb.
Quincy	Harry O. Channon.
	William Steinwedell.
Rockford	C. H. Page, Jr.
	George D. Roper.
	Henry S. Whipple.
	W. A. Wilson.
Springfield	W. Partridge.
	Emil G. Schmidt.
Sterling	Elmer Crawford.
Waukegan	H. T. Crawford.
	George F. Goodnow.

Indiana

Anderson	M. G. Reynolds.
Columbus	C. M. Keller.
Connersville	George C. Hicks, Jr.
	E. D. Johnston.
	John T. Wilkin.

Indiana—(*Continued*)

Fort Wayne	D. N. Beers.
	W. D. Birbeck.
	A. D. Cressler.
	Alfred M. Cressler.
	George H. Cressler.
	Kerr Murray Cressler.
	Fred W. Freese.
	Olaf N. Guldlin.
	G. Max Hofmann.
	Lothar Hofmann.
	Charles H. Printz.
	Theo. H. Scheumann.
	Thomas W. Stone.
	Orrell O. Thwing.
Franklin	J. S. Dales, Jr.
Gary	Leonard Fitzgerald.
Goshen	G. G. Atkinson.
Hammond	W. F. Booth.
Indianapolis	Philmer Eves.
	Carl H. Graf.
	Charles A. Meeker.
	Henry Rochat.
	George Summers.
Lafayette	S. T. Murdock.
	William Wallace.
	T. Wishart.
Michigan City	G. W. Briggs.
	S. W. Forder.
Muncie	J. E. Colvin.
New Albany	James W. Dunbar.
Peru	George M. Dolley.
	W. V. Spinning.
South Bend	A. G. Pickens.
	Benj. S. Walters.
	J. H. Warnick.
Terre Haute	F. A. Wakeman.
Vincennes	J. F. Griffin.
	Alexander Wyness, Jr.

Iowa

Burlington	Edward D. Clary.

Iowa—(*Continued*)

Cedar Rapids	A. T. Averill.
	Glenn M. Averill.
	Thomas Suchomel.
Charles City	R. K. Runner.
Clinton	Thomas Crawford.
Council Bluffs	A. L. English.
Davenport	Harold V. Patterson.
	Joseph F. Porter.
Des Moines	Jansen Haines.
	E. H. Martin.
	G. I. Vincent.
Dubuque	George McLean.
Eagle Grove	J. A. Innes.
Fort Dodge	R. M. Parker.
Fort Madison	H. H. Wilson.
Iowa City	George S. Carson.
Le Mars	O. H. Hinds.
Muscatine	Edw. M. Walker.
Oskaloosa	Campbell W. Fair.
Ottumwa	David S. Milne.
Sioux City	Wm. J. Bertke.
	C. C. Gartland.
	Leonard L. Kellogg.
	Peter N. Smith.
Waterloo	Austin Burt.
	I. C. Elston, Jr.

Kansas

Chanute	Clifton W. Sears.
Cherryvale	John C. Dods.
Emporia	H. Dunlap.
Fort Scott	Freeman Drake Martin.
Independence	William McNair Welch.
Kansas City	C. M. Cole.
	W. H. McKenzie.
Leavenworth	Edward S. Springer.
Topeka	George J. Swan.
	L. G. Treleaven.

Kentucky

Louisville	A. H. Barrett.
	Frank Huber.
	Donald McDonald.
	F. N. Sackett.
	Harry R. Swann.
Paducah	Ira C. Covert.
Richmond	Benj. A. Dougherty.

Louisiana.

Houma	I. N. Knapp.
New Orleans	Thomas David Miller.
	Richmond E. Slade.

Maine

Bangor	Vernon K. Gould.
Portland	Eugene H. Yorke.

Maryland

Baltimore	George Beadenkopf.
	E. E. Borst.
	Howard Bruce.
	C. H. Claiborne.
	Charles M. Cohn.
	Charles H. Dickey.
	Edmund S. Dickey.
	E. Bartlett Hayward.
	E. S. Newbold.
	L. Irving Pollitt.
	Louis N. Rancke.
	Edward L. Rieha.
	Harry C. Ross.
	R. S. Scott.
	Fred H. Wagner.
	Charles White.
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Frederick	J. H. Enright.
Westminster	John H. Cunningham.

Massachusetts

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Beverly	C. R. Prichard.

Massachusetts—(*Continued*)

Boston	W. B. Calkins.
	Alfred Clarke.
	Dwight T. Cortis.
	F. N. Eisenman.
	John A. Gould.
	Robert Grant.
	M. S. Greenough.
	J. R. Huntting.
	A. D. Little.
	W. E. McKay.
	Arthur E. Norton.
	Harry A. Norton.
	Theo. H. Piser.
	J. L. Richards.
	Frederick P. Royce.
	William Austin Wood.
	Edgar N. Wrightington.
Cambridge	Albert M. Barnes.
	J. P. Kennedy.
Charleston	Samuel J. Fowler.
Chicopee	Charles H. Nutting.
East Boston	N. W. Gifford.
Everett	John F. Wing.
Fall River	Charles F. Leonard.
	Joseph E. Nute.
Fitchburg	William L. Walker.
Gloucester	John A. Coffin.
Haverhill	Charles W. Morse.
Holyoke	William H. Snow.
Hyde Park	L. B. Johns.
Lawrence	C. J. R. Humphreys.
	Fred H. Sargent.
	H. G. Taylor.
Lowell	R. Buckminster
	C. W. Hinman.
Lynn	Charles F. Prichard.
Malden	C. E. Paige.
	Albert B. Tenney.
New Bedford	Charles H. Gifford.
	Robert Lindsay.
	George R. Stetson.
Newton	R. A. Fancy.
	Waldo A. Learned.

Massachusetts—(*Continued*)

North Adams	Frank S. Richardson.
Pittsfield	Harry C. Crafts .
Springfield	Benjamin P. Bill.
	Herman Burgi.
	Charles H. Tenney.
Wakefield	Albert B. Morton.
Webster	H. S. Shaw.
West Roxbury	T. J. Potter.
Worcester	Charles Dudley Lamson.

Michigan

Ann Arbor	Henry W. Douglas.
	Alfred H. White.
Battle Creek	F. K. Berry.
	D. N. Frazer.
Charlotte	Edward J. Elles.
Detroit	W. H. Allen, Jr.
	William Taft Barbour.
	W. H. Barthold.
	J. W. Batten.
	Warren S. Blauvelt.
	D. F. Burritt.
	Irvin Butterworth.
	F. L. Cross.
	V. F. Dewey.
	Alex. Dow.
	William H. Frost.
	Jules G. Hoffman.
	E. F. Hyland.
	Frank K. Lane.
	Nathan G. Leakey.
	Alfred G. Lloyd.
	Ernest F. Lloyd.
	James T. Lynn.
	J. N. McCallum.
	Howard L. Olds.
	George Osius.
	Charles S. Ritter.
	C. A. Schwarn.
	R. Shacklette.
	A. F. Shattuck.
	Otis A. Sinsel.
	Edwin G. Van Wie.

Michigan—(*Continued*)

Detroit	A. L. Wilkinson.
	L. B. Young.
Flint	Edw. J. Gutsche.
Grand Rapids	W. A. Aldrich.
	Glenn R. Chamberlain.
	Ralph S. Child.
	Edward M. Deane.
	John Hellen.
	Frank T. Hulswit.
	Richard Schaddelee.
	B. O. Tippy.
	T. J. Weber.
Hancock	Max H. Cutcheon.
Holland City	Howard Bixby.
Ishpeming	William J. McCorkindale.
Jackson	B. R. Laraway.
Kalamazoo	Walter M. Blinks.
	Frank W. Blowers.
	Charles T. Chisholm.
	W. P. Fairbairn.
	H. S. Humphrey.
	J. J. Knight.
	Wm. Thompson.
	A. L. Zwisler.
Laurium	C. C. Sloan.
Marshall	Carroll Collins.
Muskegon	John T. Young.
Port Huron	J. C. Sloan.
Three Rivers	David Elder.

Minnesota

Albert Lea	Ludwig Kemper.
Duluth	C. W. Andrews.
Faribault	B. W. Cowperthwait.
Mankato	Robert E. Brown.
Minneapolis	R. W. Clark.
	F. W. Little.
	W. J. Murphy.
	Frederick C. Shepard.
Red Wing	F. A. Willard.

Minnesota—(*Continued*)

St. Paul	John P. Crowley.
	Paul Doty.
	V. L. Elbert.
	Henry J. Gille.
	Alfred H. Linderoth.
	Bert F. Pelten.
	George Steinwedell.
	H. B. Stiles.
	A. W. Zahm.
West Duluth	W. H. Wright.
Winona	L. C. Graham.

Mississippi

Jackson	James T. Pullen.
Vicksburg	Samuel E. Linton, Jr.

Missouri

Booneville	W. E. Sombart.
Brookfield	Louis D. Kelsey.
Independence	Robert S. Miller.
Jefferson City	P. A. Bertrand.
Joplin	B. J. Crahan.
Kansas City	Byron E. Chollar.
	E. W. Hammond.
	A. Hurlburt.
	Jas. B. McGowan.
	A. B. Macbeth.
	Miss Anna Virginia Miller.
	John M. Scott.
	Mastin Simpson.
	M. M. Sweetman.
	William M. Wood.
St. Joseph	R. C. Cornish.
	Kerr M. Mitchell.
	Edward P. Snowden.
St. Charles	Edw. L. Lambert.
St. Louis	John I. Beggs.
	August Court.
	Augustin J. Daly.
	John Dell.
	William S. Dodd.
	A. C. Einstein.
	L. C. Hamlink.

Missouri—(*Continued*)

St. Louis	C. L. Holman.
	Archibald S. B. Little.
	W. A. Lockwood.
	Charles A. Magee.
	P. S. Marquis.
	Alten S. Miller.
	Roger W. Polk.
	W. S. Reger.
	Daniel R. Russell.
	Robert Seeger.
	E. J. Sherwood.
	E. H. Tinsman.
	Jacob D. Von Maur.
	W. H. Whitton.
	Leigh Wickham.
Sedalia	Wareham S. Baldwin.
Springfield	W. A. Bixby.

Montana

Helena	G. A. Strain.

Nebraska

Lincoln	B. C. Adams.
Omaha	Isaac Battin.
	G. W. Clabaugh.
	John C. Grey.
	E. B. Myers.
	George H. Waring.

New Hampshire

Concord	Henry K. Morrison.
Keene	G. M. Rossman.
Manchester	Walter G. Africa.
	Owen B. Evans.
	Alex. H. Scott.
Nashua	Walter F. Norton.

New Jersey

Atlantic City	F. B. Aldrich.
	S. Bradley.
	C. W. Hoy.
	John P. Tompkins.
Bayonne	H. A. Wheeler.

New Jersey—(*Continued*)

Camden	W. H. Allen.
	John J. Burleigh.
	George W. Curtis.
	James N. Downey.
	Harry Ellis.
	George Hobdell.
	Thomas Littlehales.
	E. A. Moore.
Cape May	O. A. Merchant, Jr.
Dover	S. H. Ely.
East Orange	W. O. Brown.
	John A. Clark, Jr.
Elizabeth	Roger Crilley.
	Francis Engel.
Englewood	W. E. Reynolds.
Gloucester City	Thomas J. Litle, Jr.
	Norman Macbeth.
	Townsend Stites.
	C W. Wardell.
	M. C. Whittaker.
Hackensack	E. C. Roberts.
	S. K. Zook.
Hoboken	John Cabot.
	W. Greacen, Jr.
	Charles J. Roeser.
Jersey City	Joseph B. Ames.
	West Bissell.
	David R. Daly.
	E. J. Donahue.
	H. H. Ferris.
	J. P. Henofer.
	A. J. Palmer.
	F. W. Schmidt.
Long Branch	F. W. Bowen.
	E. E. Eysenbach.
	D. W. Flowers.
Merchantville	J. A. Callenbach.
Montclair	J. P. Zingg.
Morristown	Robert D. Foote.
	William W. Wright.
Newark	William S. Barker.
	John H. Braine.
	William H. Chadwell.

New Jersey—(*Continued*)

Newark	Walter L. Chewning.
	P. T. Dashiell.
	J. S. DeHart.
	James P. Dusenberry.
	E. H. Earnshaw.
	W. M. Halsey.
	J. P. Hanlan.
	Thomas N. McCarter.
	Hugh K. MacDougall.
	J. G. O'Keeffe.
	W. H. Pettes.
	Geo. J. Roberts.
	J. McClellan Rogers.
	Alexander H. Strecker.
	Adolph Frederick Wehner.
	Robert K. Wehner.
	H. D. Whitcomb, Jr.
	Percy S. Young.
	R. R. Young.
New Brunswick	W. F. Thomas.
Oak Lynn P. O.	W. H. Bettle.
Passaic	J. F. Kilgour.
	C. A. Stelling.
Paterson	John Bimson, Jr.
	Theo. Bunker.
	Jas. M. Lane.
	W. H. Rogers.
	William L. Williams.
Perth Amboy	H. Foersterling.
	A. F. Reitemeyer.
Plainfield	W. R. Causebrook.
	Thomas Melick.
	D. P. Skellenger.
Rutherford	Addison Ely.
South Amboy	William E. Bedle.
Summit	M. S. Sherwood.
Trenton	Charles G. Cook.
	Frank D. Moses.
West Hoboken	James Kennedy.

New York

Albany	D. F. Brown.
	F. S. Dunn.
	John E. Gaitley.
	John J. Garrison.
	E. P. Gavit.
	Donald McDonald.
	F. McDonald.
	William McDonald.
	R. E. Sard.
	R. H. Smith.
Amsterdam	W. H. Cooper.
Astoria, L. I.	Charles Boone.
	H. E. Carpenter.
	H. S. Hudson.
	N. J. Sperling.
Bay Shore	F. S. North.
Binghamton	Chas. W. Bennett.
	Robert W. Manier.
Brooklyn	Robert Wilder Bush.
	Edward J. Byrne.
	Thomas E. Byrne.
	D. G. Fisher.
	James H. Jourdan.
	John D. Logan.
	E. H. Mathews.
	A. F. Staniford.
	Chas. M. Willis.
	H. A. Wuest.
Buffalo	H. C. Palmer.
	Walter W. Richardson.
	William S. Riselay.
Canandaigua	V. A. Miller.
Coney Island	J. J. Humphreys.
Far Rockaway	Carlton Macy.
	Lewis B. Sharp.
Flushing	M. H. Spear.
	Ed. S. Sullivan.
	W. H. Sullivan.
Geneva	E. H. Palmer.
Glens Falls	C. E. Wakeman.
Gloversville	L. D. Spragle.
	W. H. Taylor, Jr.

New York—(*Continued*)

Hempstead	S. K. Campbell.
Ithaca	William T. Morris
	T. W. Summers.
Kingston	Franklin Tobey, Jr.
Little Falls	Henry P. Collins.
Long Island City	C. Cassels Atwood.
	W. W. Burden.
	Clifford S. Fox.
	W. F. Lawrence.
	M. E. Mueller.
	Crist H. Stevick.
	C. G. M. Thomas.
Mt. Vernon	Chas. F. Bryant.
	Robt. A. Carter, Jr.
	William J. Clark.
	J. K. Crowell.
	E. B. Davis.
	J. W. Green.
	G. M. Harrison.
	Robert James Jennings.
	Alfred M. Keene.
	H. B. Kellogg.
	R. M. Kellogg.
	George T. Macbeth.
	F. M. Roberts.
Newburgh	A. R. Beal.
	William R. Beal.
	B. J. MacDonald.
	L. H. Scherck.
New York City	H. C. Abell.
	Frederick P. Addicks.
	Walter R. Addicks.
	H. W. Alrich.
	J. Charles Andrews.
	C. G. Atwater.
	C. T. Ayres.
	Anastasio C. M. Azoy.
	W. W. Barnes.
	F. R. Barnitz.
	William E. Barrett.
	Frederick C. Bates.
	Albert B. Beadle.
	Edward A. Behringer.

New York—(*Continued*)

New York City	E. W. Bell.
	Lucius S. Bigelow.
	Ben Alten Block.
	Fred L. Bradley.
	William H. Bradley.
	James C. Brady.
	Ernest C. Brown.
	H. M. Brundage.
	Milan R. Bump.
	Sterling H. Bunnell.
	J. F. Butler.
	Elbert P. Callender.
	Robert A. Carter.
	E. S. Chapin.
	Frank P. Cheesman.
	B. C. Cobb.
	Alfred S. Cooke.
	William M. Crane.
	Philip Cross.
	Roland A. Davidson.
	J. Alfred Dixon.
	R. M. Dixon.
	G. B. Dobbin.
	Henry L. Doherty.
	Parr H. Dole.
	Wm. Dougherty.
	Philip Dunne.
	W. M. Eaton.
	W. K. Eavenson.
	Harrison G. Ecker.
	A. B. Eilbeck.
	Arthur H. Elliott.
	Geo. B. Evans.
	Wm. M. Flook.
	Frederick W. Floyd.
	James R. Floyd, Jr.
	O. H. Fogg.
	Alfred E. Forstall.
	Gilbert Franklyn.
	Frank W. Frueauff.
	William H. Gardiner.
	Lewis B. Gawtry.
	Patrick Goodman.

New York—(*Continued*)

New York City	W. R. Goudy.
	Malcolm M. Graham.
	J. A. Haefelin.
	F. E. Hague.
	A. H. Hall.
	W. K. Harrington.
	G. E. Harris.
	F. S. Hastings.
	W. J. Hawthorn.
	Sterling F. Hayward.
	Geo. S. Hessenbruch.
	C. M. Higgins.
	Chas. H. Hodges.
	David Leavitt Hough.
	William Greely Hoyt.
	Alexander C. Humphreys.
	Jas. F. Hunter.
	Charles L. Inslee.
	Charles W. Isbell.
	C. N. Jelliffe.
	Mervyn E. Johnston.
	P. R. Jones.
	Edward R. Jourdan.
	Julius Kahn.
	C. F. Keegan.
	R. C. Kellogg.
	James S. Kennedy.
	I C. Kingsbury.
	I. Clayton Kingsbury.
	M. Kirchberger.
	W. J. Knothe.
	V. R. Lansingh.
	Alanson P. Lathrop.
	Albert Lauber.
	C. W. Lee.
	E. C. Leiman.
	Robert O. Luqueer.
	Joseph Lush.
	E. A. Lyon.
	J. M. McCarthy.
	J. W. McClellan.
	W. N. McIlravy.
	H. B. McLean.

New York—(*Continued*)

New York City	Emerson McMillin.
	Marion McMillin.
	George Macdonald.
	W. L. MacIntosh.
	J. H. Mansfield.
	William D. Marks.
	J. H. T. Martin.
	F. J. Mayer.
	J. Alex. Mayers.
	Jos. P. Maxwell.
	G. W. Mead.
	Robert C. Miller.
	Preston S. Millar.
	William N. Milsted.
	Clarence P. Morrell.
	W. Cullen Morris.
	Louis F. Musil.
	E. A. Nelson.
	John F. Nelson.
	Harry T. Owens.
	George Q. Palmer.
	George W. Parker.
	William P. Parsons.
	H. L. Peden.
	Irvin W. Peffly.
	Frank J. Petura.
	C. Pilz.
	Arthur Postley.
	Daniel J. Prendergast.
	George G. Ramsdell.
	William W. Randolph.
	Wm. T. Rasch.
	W. A. Richards.
	P. F. Reichelm.
	Chas. D. Robison.
	Albert Rosenthal.
	Thomas V. Rutter.
	Eugene Y. Sayer.
	F. Schniewind.
	Marvin Shiebler.
	Colin C. Simpson.
	Albert Sommer.
	W. A. Stadleman.

New York—(*Continued*)

New York City	John Stilwell.
	William Strobridge.
	Charles F. Terhune.
	Richard Henry Thomas.
	Lucien P. F. Tull.
	H. L. Underhill.
	A. V. Wainwright.
	George H. Warner.
	Albert J. Weber.
	Fred K. Wells.
	E. C. White.
	Benjamin Whitely.
	A. Whitfield.
	Charles R. Whittier.
	George Williams.
	Jas. E. Wilmot.
	Frank Wilshire.
	G. J. Wilson.
	Edwin E. Witherby.
	S. E. Wolff.
	George E. Woods.
	Arthur L. Woollen.
Niagara Falls	Albert H. Merritt.
Ossining	W. B. Clements.
	Warren L. Secord.
	H. W. Terry, Jr.
Oswego	James N. Dickerson.
Owego	A. P. Storrs.
	Charles P. Storrs.
Peekskill	Amos M. Knapp.
Plattsburgh	George M. Cole.
Port Chester	F. R. Hutchinson.
	Joseph P. Kane.
	F. M. Mills.
Poughkeepsie	T. R Beal.
	James M. Hadden.
Rochester	S. P. Cobb.
	J. C. Collins.
	James B. Eaton.
	Joseph P. Haftenkamp.
	Frank Hellen.
	James T. Hutchings.
	Herman Russell.

New York—(*Continued*)

Rochester	E. C. Scobell.
	Robert M. Searle.
	C. A. Tucker.
Rome	Roy Albright Field.
Rosebank P. O.	F. W. Sargeant.
Saratoga Springs	Patrick Roohan.
Schenectady	George Fullerton.
	M. W. Offutt.
	A. J. Smith.
	Howard L. Starr.
	V. vonStarzenski.
Stapleton	H. H. Holmes.
	Thomas O. Horton.
	H. Muller, Jr.
	William J. Welsh.
Syracuse	James C. DeLong.
	Arthur D. Dudley.
	Howard Hoffman.
	Frank F. Schauer.
	S. C. Singer.
	Fred B. Wheeler.
	Edwin C. Witherby.
Tarrytown	John A. Neth.
Troy	James H. Caldwell.
Utica	William J. Cahill.
	Herbert Gilmore Johnson.
Warsaw	W. E. Hemenway.
Watertown	John B. Taylor.
Waverly	F. A. Gillette.
West Chester	Eugene H. Rosenquest.
White Plains	E. S. Martin.
Yonkers	E. O. Baxter.
	Charles Otten, Jr.
	Hans Von Vittinghoff.
	Charles Waldron, Jr.

North Carolina

Asheville	H. W. Plummer.
Durham	R. W. Miller.
Winston-Salem	B. N. Sullivan.

North Dakota

Fargo	W. H. Thompson, Jr.

Ohio

Alliance	D. W. Low.
Ashtabula	Frederick W. Stone.
	Joseph H. Willsey.
Bucyrus	H. O. Dutter.
Canton	Joseph L. Loichot.
	Spencer S. Weart.
Chillicothe	Frederick A. Stacey.
Cincinnati	A. M. Dolph.
	C. H. Fischer.
	John Franklin.
	F. L. Garrison.
	P. H. Gibbons.
	Edward W. Hake.
	Norman G. Kenan.
	E. E. Miller.
	William A. Miller.
	James A. Reilly.
	W. H. Schmidlapp.
	Andrew J. Stacey.
	James E. Stacey.
Cleveland	Charles S. Beardslee.
	Martin B. Daly.
	A. V. Ellis.
	H. C. Fritz.
	A. L. Gassett.
	Gustavus A. Hyde.
	B. F. Klein.
	William H. Knight.
	Virgil G. Marani.
	Melvin Pattison.
	A. T. Perry.
	Pierre Plantinga.
	Arthur M. Smith.
	W. E. Steinwedell.
	W. W. Stephens.
	Frank E. Taplin.
	H. J. Trenkamp.
	Daniel R. Warmington.
	George H. Warmington.
	J. G. Way.
	Holley G. Wellman.
	George W. York.

Ohio—(*Continued*)

Columbus	J. M. Garard.
	Alan Leamy.
	William R. Powell.
	James P. Strickler.
	Henry D. Turney.
Dayton	Edward H. Light.
	George Light.
	W. W. Price.
	George M. Smart.
	Frank M. Tait.
Delaware	J. W. Davis.
	Thomas Clive Jones.
Hamilton	Lazard Kahn.
Lima	S. E. Mulholland.
	John D. S. Neely.
	M. L. Neely.
Lorain	Daniel Roesch.
Mansfield	William C. Hedges.
	C. W. Upson.
Marion	George Whysall.
Massilon	Robert R. Choate.
Middletown	G. N. Clapp.
Newark	Melville Gillett.
Portsmouth	John R. Lynn.
Toledo	J. R. Cunningham.
	Jos. E. Lockwood.
Warren	George Daugherty.
	John C. Gorton.
	George H. Tayler.
Youngstown	Fred S. Coombs.
	Moses Coombs.
Zanesville	Edwin Weisgerber.

Oklahoma

Muskogee	Henry H. White.

Oregon

Portland	Walter S. Dole.

Pennsylvania

Allegheny	Herbert J. Long.
	John Young.

Pennsylvania—(*Continued*)

Allentown	William F. Brodnax.
	John A. Frick.
	John J. Gannon.
	E. Johnston.
Altoona	Benjamin W. Perkins.
	William H. West.
Ambler	Arthur R. Cruse.
Ardmore	George B. Bains, 3d.
	John L. Mather.
Avondale	J. B. Thomas, Jr.
Bethlehem	James W. Murdock.
Bolivar	N. A. Young.
Bradford	George P. Boothe.
	S. R. Dresser.
	Fred A. Miller.
Carbondale	Chas. L. Rowland.
Catasauqua	G. W. Steele.
Chester	Hugh Carlton Aiken.
	A. L. Milligan.
	John D. Shattuck.
	C. R. Stull.
	George W. Thomson.
	Charles Wilde.
Coatesville	W. J. Phifer.
Danville	George M. West.
Darby	Charles J. Fox.
Easton	B. F. Cresson.
	Edwin G. Holzer.
	Ward Wilson.
East Pittsburg	Thomas C. Clifford.
	E. D. Dreyfus.
Erie	Albert MacDonald.
	F. H. Payne.
Fort Washington	William Hobson Vollum.
Greenville	A. C. Hartzell.
Hanover	R. H. Dutton.
Harrisburg	A. S. Graham.
	Luther S. Williams.
Irwin	Edwards F. Wilson.
Johnston	William H. C. Ramsey.
Lancaster	B. H. Spangenberg.
	C. E. Titzel.
Lebanon	W. H. Merritt.

Pennsylvania—(*Continued*)

Lewistown	Eugene F. McCabe.
Milton	C. W. Butterworth.
Norristown	Herbert H. Ganser.
Philadelphia	H. C. Adams.
	E. R. Alburger.
	Walter A. Allison.
	F. M. Arthur.
	James Ball.
	Geo. J. Barnes.
	J. C. Bartlett.
	Geo. S. Barrows.
	Henry S. Battin.
	Walter W. Beaumont.
	C. M. Benedict.
	Samuel Taylor Bodine.
	Charles O. Bond.
	Cyrus Borgner.
	Albert M. Boyd.
	Lynn H. Boyer.
	Ernest L. Brundrett.
	H. B. Bryans.
	Matthew W. Butler.
	William H. Butler, Jr.
	Henry R. Cartwright.
	William A. Castor.
	Henry B. Christy.
	Walton Clark.
	W. W. Cole.
	H. W. Coleman.
	David J. Collins.
	E. M. Colquhoun.
	Roger B. Combs.
	H. R. Cook, Jr.
	F. G. Corbus.
	G. W. Crawford.
	J. A. P. Crisfield.
	G. W. Curran.
	Samuel P. Curtis.
	R. E. Dallas.
	H. W. Davies.
	Mark Dean.
	Carl A. Dickel.
	S. J. Dickey.

Pennsylvania—(*Continued*)

Philadelphia	William F. Dorner.
	James B. Douglass.
	W. F. Douthirt.
	Arthur D. Dudley.
	N. A. Dutton.
	W. G. Earnshaw.
	Walton Forstall.
	John Fowler.
	J. Scott Fowler.
	W. B. Franklin.
	Walter H. Fulweiler.
	William H. Gartley.
	T. Bertram Genay.
	Thomas S. Genay.
	Thomas L. George.
	Francis H. Gilpin.
	H. W. Graeff.
	Albert Green.
	John Gribbel.
	H. O. Gross.
	Charles F. Hardick.
	C. Willing Hare.
	William E. Helme.
	G. R. Hemminger.
	G. R. Horning.
	Abram C. Howard.
	J. H. Hubbs.
	Robert C. James.
	William Kane.
	John Bartleman Klumpp.
	P. J. Lafore.
	W. P. Lane.
	W. W. Levering.
	Lewis Lillie.
	H. Livingston.
	Joseph Lucena.
	John McIlhenny.
	John D. McIlhenny.
	Andrew P. Maloney.
	William H. Marshall.
	Sidney Mason.
	Martin Molony.
	F. N. Morton.

Pennsylvania—(*Continued*)

Philadelphia	Joseph B. Myers.
	Carroll B. Nichols.
	Rollin Norris.
	Charles M. O'Connell.
	C. J. O'Donnell.
	T. Brandon Ordish.
	Edward Page.
	Joseph Smith Parker.
	W. F. Pearce.
	Joshua Ashe Pearson.
	M. F. Perkins.
	Rowan P. Perkins.
	Joseph A. Perry.
	Charles J. Ramsburg.
	Clarence V. Roberts.
	Edward H. Rodgers.
	William L. Rowland.
	John M. Rusby.
	John M. Ruegenberg.
	F. J. Rutledge.
	J. Fred Seamon.
	Jas. R. Schurtz.
	William J. Serrill.
	C. D. Shaw, Jr.
	Frederick H. Shelton.
	Howard R. Sheppard.
	John W. Smith.
	William Henry Smith.
	Charles S. Snyder.
	Henry Steck.
	Jacob W. Stirzel.
	Morris W. Stroud.
	J. Hawley Taussig.
	A. C. Taylor.
	Richard H. Thomas.
	Paul Thompson.
	Fred G. Thorn, Jr.
	William Nichols Tolman.
	R. H. Trimble.
	C. A. Turner.
	Carrington Cabell Tutwiler.
	Charles N. Vollum.
	John S Welch.

Pennsylvania—(*Continued*)

Philadelphia	F. V. Westermaier.
	Henry Wharton.
	Thomas G. Williams.
	Edward R. Wood, Jr.
	George B. Wood.
	Stuart Wood.
	G. H. Woodall.
	Louis N. Yetter.
Pittsburg	George W. Barnes.
	J. K. Beatty.
	Arthur Booth.
	Alfred P. Brill.
	H. A. Carpenter.
	R. C. Frampton.
	Charles L. Gerould.
	Joseph F. Guffey.
	William H. Hammon.
	F. J. Laird.
	Mark Leavenworth.
	Edw. D. Leland.
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	G. R. Nutty.
	Willard B. Osborne.
	Roland G. Porter.
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	Edwin Ruud.
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	Samuel B. Stewart.
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	Robert Young.
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Pottstown	Herbert G. Williams.
Pottsville	R. C. Morris, Jr.
Reading	John H. Keppelman.
	John E. Morgan.
Royersford	John H. Mansur.
Scranton	William McKelvey Marple.
	W. E. Mockett.
	Worthington Scranton.
Steelton	J G. Diffenderfer.

Pennsylvania—(*Continued*)

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Tidioute	William Hague.
Westchester	William O. Lamson, Jr.
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	J. Hugh Perkins.
Williamsport	Ernest H. Davis.
	Wm. R. Rhoades.
Wyncote	Lewis R. Dutton.
York	F. R. Smart, Jr.

Rhode Island

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Pawtucket	Frederick W. Easton.
	William McGregor.
Providence	George A. Allyn.
	W. C. Buell, Jr.
	Edmund Cathels.
	John W. Ellis.
	Carroll Miller.
	W. H. Price.
	A. B. Slater.

South Dakota

Aberdeen	Charles A. Howard.
Sioux Falls	Chester N. Chubb.
Watertown	H. E. Morton.

Tennessee

Jackson	H. E. Kincaid.
Knoxville	C. C. Durkee.
	Alfred W. Young.
Memphis	Richard Rees.
	Charles H. Stevens.
	L. A. Van Ness.

Texas

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Beaumont	M. T. Walker.
Dallas	C. W. Tippy.
El Paso	Thomas J. Jones.
Fort Worth	H. G. Stillson.
Houston	C. H. Dunbar.

Texas—(*Continued*)

San Antonio	G. H. Cushman.
	G. J. Houston.
	L. B. Moorhouse.
	L. H. Onderdonk.
	W. B. Tuttle.

Utah

Salt Lake City	L. L. Cadwallader.
	J. Charles Ross.

Vermont

Burlington	Frank H. Parker.

Virginia

Charlottsville	H. M. Hantzmon.
Danville	Frank Talbot.
Fredricksburg	B. F. Bullock.
Hampton	F. L. Marshall.
Norfolk	Frederic Egner.
	E. C. Hathaway.
	R. J. Marks.
	F. H. Sawyer.
Petersburg	E. C. Pond.
Portsmouth	B. B. Ferguson.
Richmond	William P. Knowles.
Roanoke	E. M. Funkhouser.
	A. G. King.

Washington

Seattle	Charles Russell Collins.
	Frederick K. Lane.
Spokane	A. N. Cantril.
	E. H. Gimper.
	E. G. Pratt, Jr.
Tacoma	Henry H. Hyde.
	W. A. Leuenberger.
	William W. Seymour.

West Virginia

Fairmount	H. A. Roesler.

Wisconsin

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Beloit	B. F. Lyons.
	E. D. V. Dickey.
Berlin	Thomas B. Wood.
Janesville	I. F. Wortendyke.
Kenosha	Roger N. Kimball.
Madison	C. F. Burgess.
	John Corscot.
	O. L. Kowalke.
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Milwaukee	Fred Bredel.
	R. B. Brown.
	Sheldon J. Glass.
	O. F. Greim.
	Ewald Haase.
	Henry M. Humphreys.
	W. F. Hyde.
	R. P. Kraft.
	M. N. Latta.
	Bryce McAdam.
	John T. Mason.
	J. C. Shirra.
	L. M. Whitwell.
	A. C. Wilke.
Oshkosh	Sinclair Mainland.
	William Mainland.
	O. G. F. Markhus.
Watertown	Charles Mackay.
	P. L. Utley.
Waukesha	H. M. Buck.
Winonah	J. A. Patten.

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Belgium

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Canada, Alberta

Calgary ..... A. I. Payne.

Canada, Ontario

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Hamilton ..... William Gibson.
John Keillor.
John B. McNary.
Toronto ..... Frederick Burnett.
L. L. Merrifield.
W. H. Pearson.
W. H. Pearson, Jr.
Robert Bruce Steward.
Ottawa ..... Charles Forbes.

Canada, Quebec

Montreal ..... Howard E. Mann.
Samuel Skinner.
Quebec ..... Carl Steinwedell.
R. A. Wallace.

England

London ..... F. A. Angell.
L. D. Carroll.
Arthur G. Glasgow.
H. M. Hodson.
Frederic Thuman.
John Townsend Westcott.

Japan

Nagoya ..... Sakura Okamoto.
Osaka ..... Chas. P. Cushman.
Tokio ..... Suyekichi Hiramatsu.

Newfoundland

St. Johns ..... W. H. Rennie.

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Iowa	27	Vermont	1
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Louisiana	3	West Virginia	1
Maine	2	Wisconsin	37
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